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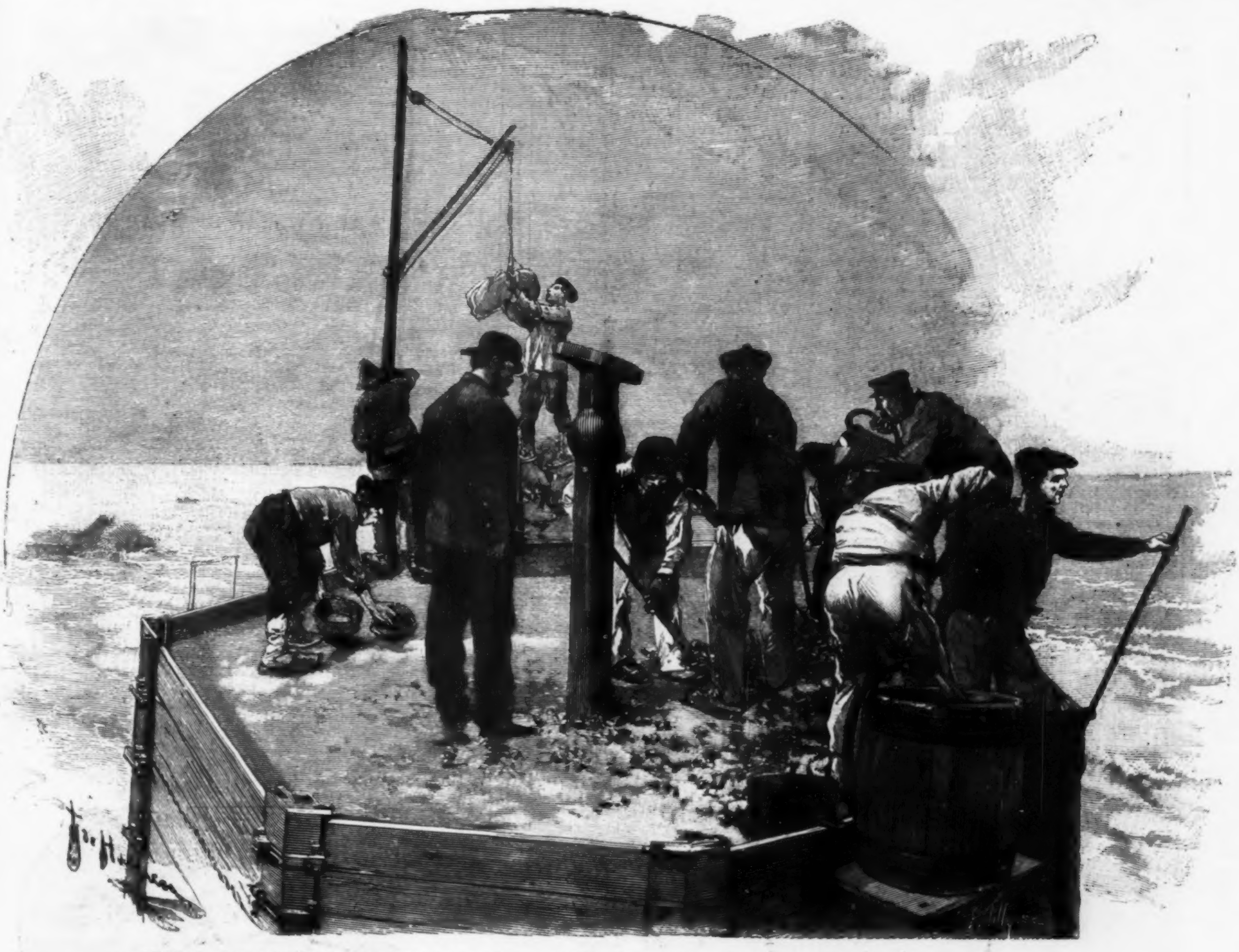
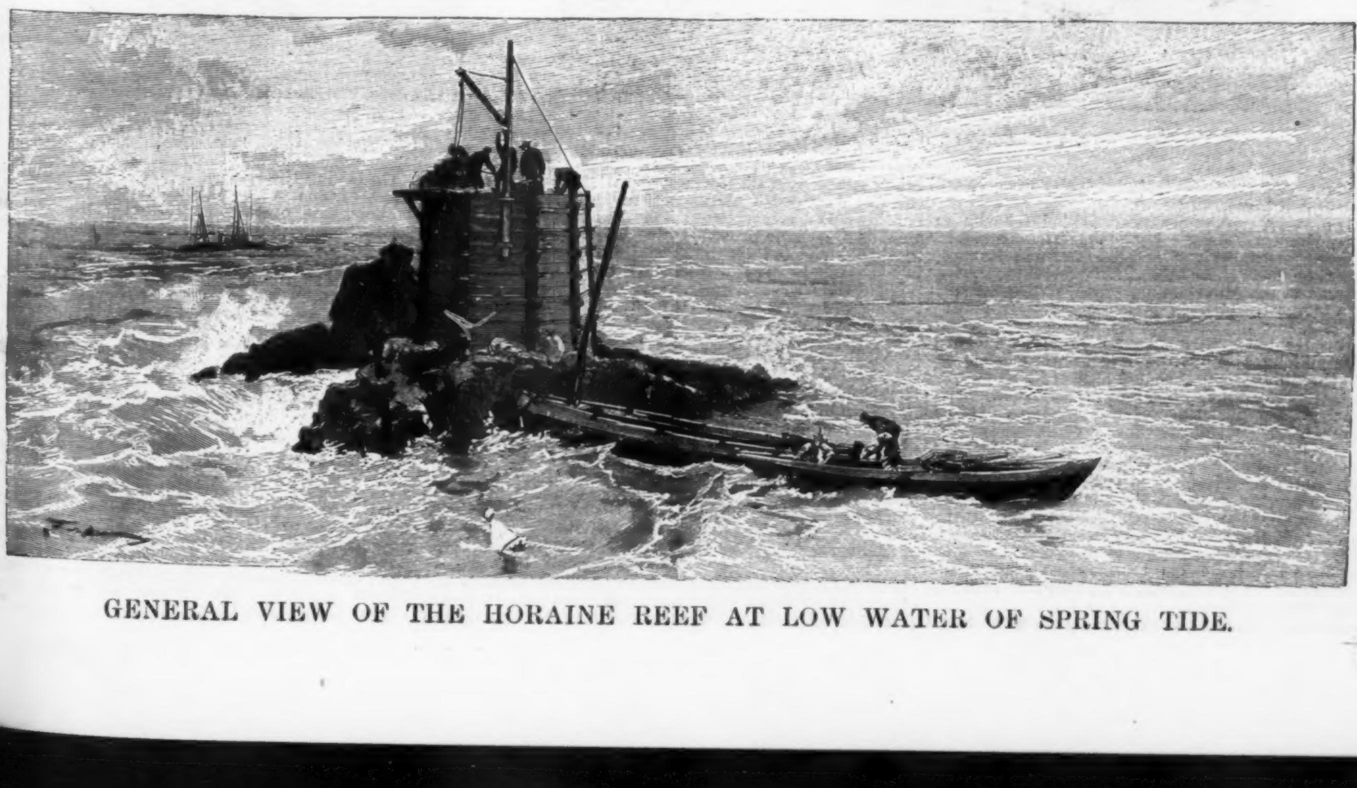
THE BEACON TOWER OF THE PLATEAU OF HORAINE.

THE administration is often joked that "Europe envies us," and this is right, but it is too readily forgotten, too, that the serried ranks of the administrative army comprise a host of devoted functionaries who give the state their intelligence and their labor in exchange for a paltry salary, and whose work is the glory and the fortune of the country. Such is, among others, the corps of government engineers, and particularly the service of lighthouses and beacons, the truly admirable work of which we have several times had occasion to call attention to.

This work is almost unknown to the public at large. It is vaguely known that the coasts of France, especially those of Brittany, are covered with dangerous rocks, but the fact is unknown that these rocks are now marked and labeled in such a way that the navigator can sail among them and recognize them, just as a stranger recognizes by their sign boards the streets of a city of which he has a plan. One has scarcely any suspicion of the patient, obstinate and perilous work that it has required to place upon these rocks and these banks of sand lashed by the sea the lighthouses, buoys and beacons that mark them. We are going to try to give some idea of it by describing



THE BEACON OF HORAINE—THE PLATFORM DURING THE WORK.



GENERAL VIEW OF THE HORAINE REEF AT LOW WATER OF SPRING TIDE.

what has just been done upon the plateau of Horaine, one of the most formidable rocks of the north coast of Brittany.

The plateau of Horaine is a chain of rocks situated four miles seaward of the island of Brehat. It is nearly a mile and a quarter in length. At low tide, the rocks there everywhere show their blackish heads in the midst of the white foam of the breakers; but after the tide has risen, no sign upon the surface of the water any longer reveals these perfidious rocks upon which a ship may go to destruction, hull and cargo, without anything having warned it of their presence.

Let us add that in the vicinity of Horaine the currents have a velocity of six miles an hour, that their direction varies at every instant and that fogs are frequent in the locality, and we shall have an idea of the danger of navigation in these quarters.

A vain attempt has been made for the last forty years to provide the highest of these rocks, situated at the west of the plateau, with beacons. The sea, which becomes furious at the least breeze in the midst of all these obstacles, quickly got the better of the most solid structures. After many fruitless tentatives, there was successfully sealed into the rock an iron girder four inches in thickness which stood vertically in the midst of the waves; but it was broken like a straw at about three feet above the granite, and the part remaining was twisted.

Later on, in 1890, six holes were drilled for the reception of the uprights of a hexagonal structure. By way of experiment, an iron post 6½ inches in diameter was placed in one of these holes. This resisted for nearly two years, and was then broken off flush with the rock during a tempest. It became necessary to renounce this project, but the enterprise was not abandoned, and it was decided that the construction of a masonry tower should be attempted. This was to again aggravate the difficulties. Let us judge of it. The rock selected, after careful exploration, is ten feet below the surface at the highest tides of the equinox. It was impossible to lay the foundations except at four feet above the level of the lowest water. Now, low tide reaches this level only very exceptionally. There were no more than four days per month in which it was possible to work for about an hour upon the site. Again, it required calm weather, and when in the course of this hour of exciting work, one had succeeded in laying a few courses of masonry upon the granite, he would have found in most cases everything swept away at the subsequent trip, had the ordinary processes been employed.

A beginning was therefore made by constructing a wall of bricks, which was filled in with concrete made of slow-setting Portland cement.

Once at the level of the rock, the construction of an eight-sided tower inscribed in a circle of twenty feet in diameter was begun. This tower was to be fifty feet in height above the rock.

Cast iron corner posts eighteen inches in height, placed at each angle and fixed to the rock, contained grooves that permitted of the sliding of spruce joists that were firmly wedged. In this way there was obtained a very strong wall that was filled in with concrete prepared upon the spot.

In measure as the filling in proceeded, angle pieces were superposed and fixed with three bolts.

In order to prevent the destruction of the concrete by the lashing of the waves, a sail cloth loaded with pigs of iron was employed; but at a certain height the canvas was torn and disappeared with its load. Then one was led to protect the work by means of panels of wood fixed to the interior of the inclosure, and solidly shored against the walls. This succeeded perfectly until the wind storm of the beginning of September last, which tore everything away. The concrete alone had but slightly suffered.

The concrete was manufactured at the top of the tower upon plank platforms. In order to have sufficient supplies, a platform was installed at every tide on the outside of the inclosure and served as a deposit for the materials in bags that were hoisted by means of a crane provided with a jib and pulley blocks and tackle that took the material from the rock upon which it had been unloaded or from boats lying alongside of the rock.

The water for the mortar was furnished by a pump placed on the outside and which debouched in a tank, which also was outside of the inclosure.

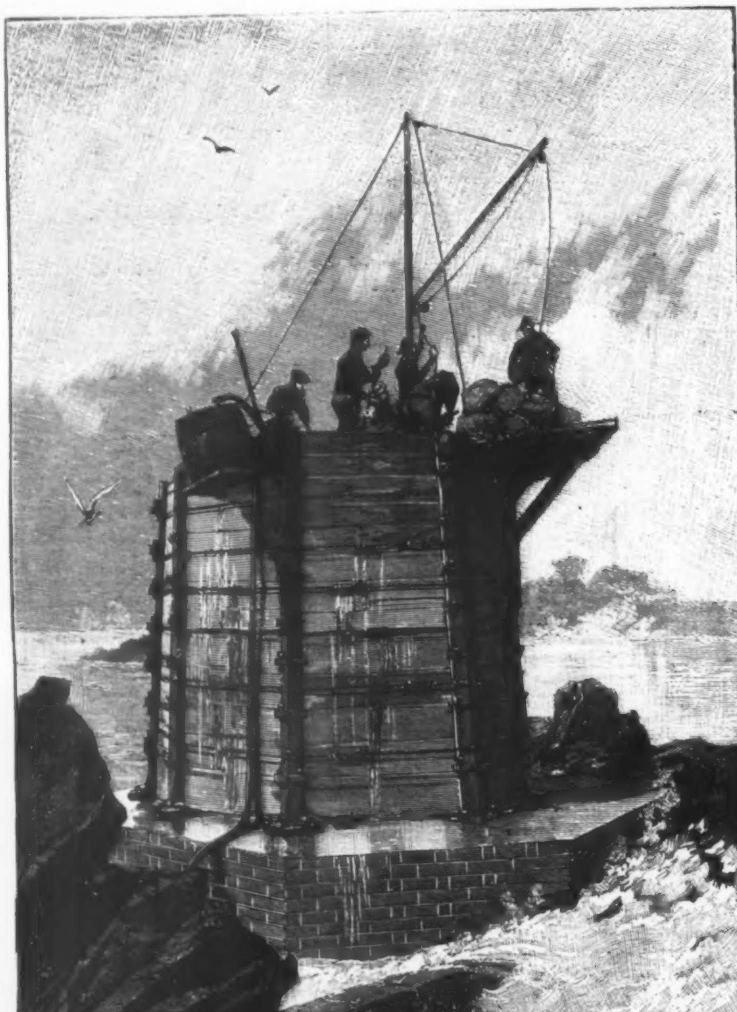
All these installations of wood, comprising protecting panels, platform planks, the supports for the latter and the crane and jib, water tank, etc., were put in place in a very short time.

The personnel consisted of seafaring men who were well under the hand of their superintendent, and who were devoted and interested in their work and labored in silence with a perfect understanding and with hearty will.

Our engravings show the details of this temporary installation which it was necessary to establish and take apart forty times before the desired height was reached. They show, too, the aspect of the tower in process of construction at low water of spring tide, and then at half flood, when the rock has already disappeared under the water, and finally at high tide, when the masonry, covered in its turn, no longer reveals itself except by a light breaker.

The tower was then at about a sixth of its height. The continuous bad weather has, since the middle of October, necessitated a suspension of the work, which will not be resumed until next spring.

Let us hope that it will triumphantly resist the furious assaults of the winter waves, and that, at a corresponding epoch next year, it will stand immovable amid the billows, like a modest and admirable monument of what the patient effort of a few courageous, intelligent and tenacious men may be against the blind forces of nature.—L'Illustration.



THE CONSTRUCTION AT LOW TIDE.

AT LOW WATER OF NEAP TIDE.

AT HALF TIDE.

AT HIGH TIDE.

A GAS ENGINE DIFFICULTY.

A PECULIAR trouble encountered in connection with two gas engines, at Munich, Germany, one of 25 and one of 50 horse power, is related by M. Trillich, in the Bayerisches Industrie und Gewerbeblatt. After having been in operation for about a year, different parts of the engines, notably the exhaust valves, were frequently found to be very much overheated, the circulation of the cooling water through the cylinder jackets was impeded, and there were often premature explosions of the gas and air charges in the cylinders.

On taking the engines apart it was found that portions of the water pipes leading to and from the jackets, and even the interior of the jackets themselves, were almost completely choked up with a scaly deposit formed by the precipitation by heat of salts dissolved in the water, the action being in all respects similar to that going on in a feed water heater.

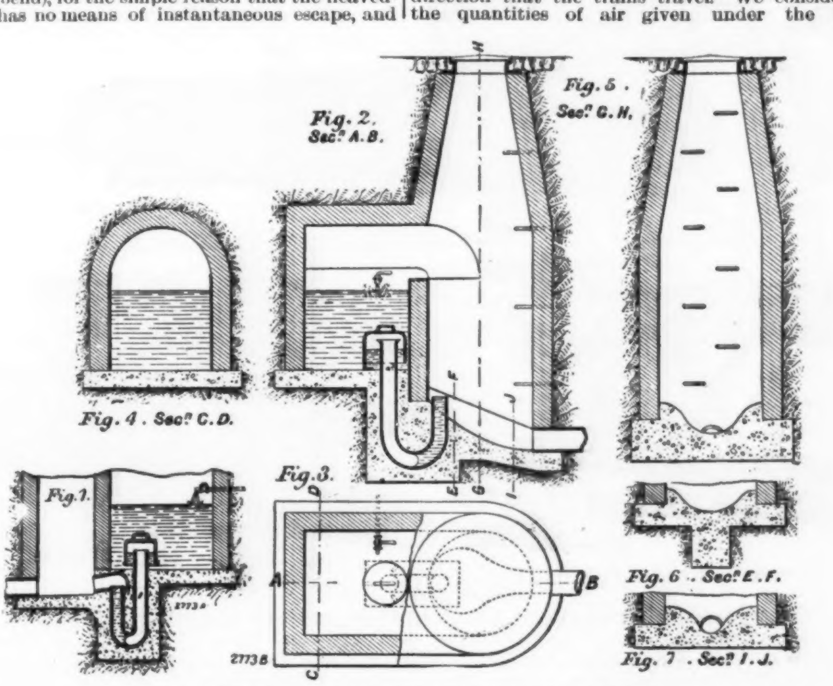
Since, however, as shown by thermometric measurement, the cooling water in flowing through the jackets while the engines were working never reached the temperature at which lime salts are known to separate from the water which holds them in solution, it became evident that the precipitation must have occurred during the periods first after the engines stopped working. During these periods the flow of water through the jackets ceased, and the water in them was raised sufficiently high in temperature by the adjoining parts of the engines to permit the separating out of the dissolved solids.

Mr. Trillich accordingly emphasizes the importance of keeping up the flow of cooling water through the jackets after the engines have been stopped until all parts of the cylinders have become quite cool. No deposit of solid matter will then take place. He recommends, also, the use of soft water for circulation through the jackets.

[FROM ENGINEERING.]

THE MILLER AUTOMATIC FLUSHING SIPHON.

THE flushing siphon which we illustrate is one which has been largely adopted in the United States, having obtained the highest award at Chicago in 1893. Previous siphons have been brought into action by the simple release or rarefaction of the air confined in the siphon, or by the sudden removal of such air by special subsidiary devices, which are entirely absent in the Miller siphon. As shown in Figs. 1 and 2, it consists of two simple castings, a U tube or trap and mouthpiece, cast in one piece, and a cast iron bell which is placed over the longer leg of the siphon, and is held in place by brackets cast on the trap. The action of the siphon is as follows: As the water entering the tank rises above the lower edge of the bell it incloses the air within, the lower portion of the U or trap being, of course, filled with water. As the water level in the tank rises, the confined air gradually forces the water out of the long leg of the trap, until a point is reached when the air just endeavors to escape round the lower bend. Now as the difference of water level in the two legs equals the difference of the levels between the water in the tank and the water within the bell, it will be seen that the column of water in the short discharge leg has practically the same depth as the head of water in the tank above the level at which it stands in the bell. The two columns of water, therefore, counterbalance each other at a certain fixed depth in the tank. As soon as this depth is increased by a further supply, however small, a portion of the confined air is forced around the lower bend, and by its upward rush carries with it some of the water in the short leg, thus destroying the equilibrium. But the secret of this invention is the free projection of the overflow edge, which allows of the instantaneous escape or falling away of the heaved-up water. Thus, if the discharge mouth were formed as an ordinary bend, the siphon would not act (although the confined air rushes around the lower bend), for the simple reason that the heaved-up water has no means of instantaneous escape, and therefor the equilibrium is not sufficiently disturbed. It will thus be seen that the action of the siphon depends, not on the escape of air, but on the sudden reduction of a counterbalancing column of water.



THE MILLER AUTOMATIC FLUSHING SIPHON.

Repeated trials have shown that a 6 in. siphon will discharge full bore a 500 gallon tank, fed so slowly as only to be filled in 14 days. There being no internal obstruction, the discharge is extremely rapid. There is, it will be seen, a deep water well between the flushing tank and the sewer, which is of course an advantage. We have had the opportunity, says Engineering, of seeing one of these siphons at work in the excellent Sanitary Museum at Hackney, and though severely tried, the siphon worked perfectly. As will be seen by a reference to Figs. 2 to 7, the siphon chamber can be very neatly combined with a manhole. No special mouthpiece is then required; the mouth of the discharge pipe stands quite clear, and delivers the water into a concrete basin, from which it rushes down into the sewer.

[FROM THE ENGINEER.]

THE SIMPLON TUNNEL.—IV.*

"II. VENTILATION.—(6) Are the methods of ventilation which have been proposed to be recommended, and will the quantities of air which they are expected to furnish, be sufficient: (a) During the construction of the first tunnel. (b) While the first tunnel is being used for traffic, and with the parallel heading for ventilation. (c) During the alteration which will take place, if heading No. II is converted into a tunnel parallel to the first one. (d) While the two tunnels are both being worked as single line tunnels. If any alterations be considered necessary in the method of ventilation, what should they be, and what would be the smallest quantity of air necessary for ventilation in each of the four above mentioned cases?

"Having carefully examined the subject, we recommend the following methods of ventilation, which to some extent modify the arrangements proposed in the contract. (a) During the construction of the first tunnel: The ventilation shall be carried out by means of air forced into heading II. This air will be cooled when the external temperature renders it necessary by means of water sprays, and its volume shall be 1,750 cubic feet per second for each half of the tunnel. The speed of the current of air which will be established in heading II will not exceed 20 feet per second. All working faces will be supplied with air from this heading, either directly or by means of water injectors. Heading II and the transverse passages are to have double doors, so as to maintain the necessary pressure in the furthest workings. In heading II the space between these doors will depend on the length of the trains; in the transverse passages the doors are to be placed at the two ends. (b) While the first tunnel is open for traffic, with the parallel heading for ventilation: The two entrances of tunnel I are to be provided with doors, and have signals to correspond. All the transverse passages are to be opened; tunnel I and heading II are to be closed at the end where the fan is working. The turbines and blowers at the northern end and those at the southern end will be used alternately for fixed periods. The quantity of air per second passing from north to south is to be increased to 2,000 cubic feet. (c) During the possible transformation of the parallel heading into a tunnel the two entrances of tunnel I are to be provided with doors, having signals to correspond. The transverse passages will be closed; tunnel I and heading II will be closed at the end at which the fan is working. The tunnel will be ventilated by the machinery at the northern end, and the parallel heading by that at the southern, or the reverse. The quantity of air for tunnel I shall be 1,750 cubic feet per second, and the same for heading II. (d) When both tunnels are open to traffic both ends of both tunnels are to have doors, with corresponding signals. All the transverse passages shall be closed. From 1,750 to 2,120 cubic feet of air per second shall be forced into the northern end of the eastern tunnel, and the same quantity into the southern end of the western tunnel—i. e., in the same direction that the trains travel. We consider that the quantities of air given under the letters, a, b, c, and d, will always be sufficient, and that the air will never contain a quantity of noxious gas large enough to exercise an unfavorable effect on human beings. This opinion is based on experiments made at the Mersey Tunnel, Liverpool. The quantity of air forced into that tunnel is 11,000 cubic feet per second, the number of trains twenty-four per hour, and the gradients 1 in 30; and in some places 1 in 27. As at Simplon the steepest gradient is 7 per mil, and the maximum number of trains four per hour, the stipulated quantity of air will be ample. If the machinery at one end should be prevented from working, that at the other will suffice for the whole of the ventilation. This is naturally under the condition that the construction of the fans, and the arrangements of the motive power, are carried out so as to allow of the fans doing double work. So that the ventilation may be efficacious, the doors are not to be constructed of canvas, but are to have solid panels, and be completely air tight. For the same reason, we recommend that fans shall be used which have the lowest possible tangential velocity. As soon as the doors at the ends are in communication with the distance signals, and there is a certainty that they will work properly, there will be nothing in these arrangements to impede the traffic. Similar arrangements have been made at the entrances of the Semmering Tunnel—1,565 yards long—on the line between Vienna and Trieste. The doors were put up thirty-nine years ago, to prevent the formation of ice during the winter; and though there is a double line and considerable traffic, they have never caused any inconvenience. A system of ventilation in which doors are not required has been tried recently in Italy, on the lines from Faenza to Florence, and Bologna to Florence. It is the invention of the engineer, M. Saccardo, and is based on the principle of the Giffard's injector. The air is injected by a fan across an annular opening beyond the mouth of the tunnel, and thus draws through the mouth a considerable quantity of air. If the experiments which are now being carried out on the Saccardo system at the Prachia Tunnel—1 mile 1,223 yards long—on the line from Bologna to Florence, give favorable results, it would be preferable to adopt it for the Simplon, as it would simplify the work. We would here remark that this system can be used with doors; as when the door is closed, it works like the ordinary method of ventilation already described, while during the time the doors are open it continues to work, so that the ventilation is never interrupted.

"(7) What is the greatest velocity at which the air should be allowed to travel in the tunnels or headings, either during construction or afterward?

"Generally speaking 20 feet per second, in either tunnel or headings, during construction, or when open for traffic.

"(8) Are the means proposed for cooling the air and the rock in the underground workings during construction adequate? Will it be necessary to employ similar measures when the tunnels are open for traffic?

"The means proposed for lowering the temperature of the air, and of the rock in the interior of the tunnel, during the period of construction are sufficient. The experts then give a calculation, based on the temperatures observed at the Gothard Tunnel, according to which the maximum temperature in the center of the Simplon Tunnel should not exceed 102° F.; and say that on account of the irregular nature of the surface, and the position of the strata, they think it is likely to be less, rather than more, than that figure. Experiments made at Winterthur show that a spray of water at 54° under a pressure of 82 pounds will easily lower the temperature of air from 100° or 120° to 60°. This cooling effect will be still greater when water is used at a higher pressure; and it is to be presumed that ozone will be produced by the process, and thus render the air richer in oxygen. The water supply will be so great that it will be possible to carry on the cooling process on a very large scale; it may, therefore, be supposed that the clause in the contract which stipulates that the temperature at the working faces should not exceed 77° will be easily kept. Besides this, there are so many cases in which it has been proved that men can work in temperatures up to 120° F., that we are convinced they can stand not only 77° at Simplon, but even 90°, provided there are frequent shifts, and that the sanitary condition of the men is carefully watched. It will tend still further to keep the works cool, if the headings are lined with closely jointed boards, or some other non-conductor, to prevent the radiation of the rock. When used for traffic, these means of cooling will not be required. Both at Gothard and Arlberg, it was found that the temperature became considerably lower after the completion of the tunnel. That of the Gothard was taken at two places, the one being 4 miles 944 yards from the northern end, and the other 4 miles 671 yards from the southern. At the former the temperature in May, 1880, averaged 87° F.; in June, 1882, it was 75°; and in July, 1885, it was 72°. At the latter the temperature was 87° in May, 1880; 74° in June, 1882; and 73½° in July, 1885. At the Arlberg Tunnel the observations were made at a point 3 miles 298 yards from the eastern end, and it was found that in September, 1883, the temperature averaged 65°. In January, 1885, it was 59½°; 58½° in January, 1886; 58° in January, 1887; and 57° in January, 1894. These two tunnels have only natural ventilation, and during construction no special means were adopted for ventilation or cooling the air. At Simplon, on the contrary, the supply of air will be very great, even during construction. It may also be expected that the cooling by means of water jets will give very favorable results. Finally, it should be observed that the parallel positions of the two excavations, tunnel I and heading II, or tunnels I and II and the tranverse passages, should have a marked effect in cooling the rock. After tunnel I is completed, the water conduits will still be available, so that the experiment can be tried whether the advantage will be sufficiently important to justify the expense which would be incurred in maintaining these conduits in working order, for the sake of being able to cool the walls. If water is sprayed in the tunnel when open for traffic, it will serve not only for cooling, but also for the absorption of carbonic acid and the production of ozone.

"III. Traffic.—(9) Can the work of the tunnel be carried on in the manner proposed (a) by one tunnel with a single line and with a parallel heading for ventilation; (b) by two parallel tunnels, each for a single line?

"Working with one single line tunnel and a parallel heading, as proposed, is possible by the application of artificial ventilation according to the methods we have already discussed, on the condition that the heading and transverse passages be lined with masonry wherever this is rendered necessary by the quality and structure of the rock, so as to prevent any possibility of the ventilation through the passages being impeded by ground falling in. The locomotives must be so constructed that there shall be perfect combustion of fuel, so that they may only produce carbonic acid. According to observations made at Arlberg, the infection of air by carbonic acid is not as dangerous as is believed, because the carbonic acid is absorbed to a great extent by the humidity of the walls and by the steam which escapes from the locomotives. At Simplon the conditions will be even more advantageous, because, if necessary, it will always be possible to absorb carbonic acid by means of water sprays. The sulphurous acid contained in the smoke is oxidized by the ozone produced by the water spray, converted into sulphuric acid and then absorbed by the water. This was proved by the chemical analysis of the air, the water, the mortar of the masonry, the rust from the rails and the sleepers of the Arlberg Tunnel. Carbonic oxide and the hydro-carbonates are peculiarly injurious to organic life.

"When air only contains 0·03 per cent. of carbonic oxide, the action of this gas can already be noted; and when the proportion arrives at 0·3 per cent. it becomes very dangerous. It is not absorbed by water, and forms very easily when there is imperfect combustion. It is for this reason that at the Arlberg Tunnel they only use coke of the best quality and as dry as possible. Experience proves, however, that if the fuel on the fire bars is too thick, or if the coke is not quite dry, carbonic oxide will still be formed, rendering it impossible for men to work if the air remains stagnant a certain time. To obviate this inconvenience, we recommend that the coke used should be thoroughly dry and of the best quality to keep up the fire in the locomotives while passing through the tunnel, and that

* Continued from SUPPLEMENT, No. 1000, page 15982.

combustion should be helped by a spray of petroleum, which will cause the complete conversion of the carbon in the fuel into carbonic acid. It should also be stipulated that the signal boxes at either end of the tunnel and that in the middle are warned every mile of the progress of the train by electrical appliances on the rails. It will also be possible to work two parallel single line tunnels, as explained in the project, if the measures of safety named above are applied. For reasons which relate both to traffic and maintenance, we consider that it will be necessary to keep up the passing place in the middle of No I tunnel, even after the completion of No. II, and to establish bell signals and telephones in each room. Also, to facilitate maintenance, a certain number of the transverse passages must be used for storing rails.

"(10) Is the loop line in the center of the tunnel to allow trains to cross a suitable arrangement?

"The crossing of trains by means of the loop line which it is proposed to make in the interior of the tunnel can take place with sufficient security, provided the signalmen at the passing place are kept regularly informed of the movement of the trains by means of electric signals, and provided the points at either end of the passing place are covered by optical as well as by audible signals. To insure safety, it is necessary that there should be at least two competent signalmen at this passing place, so that if one is indisposed, the other can take charge immediately. We have already mentioned in our reply to question No. 5 that we consider the requirements of the traffic make two rooms necessary at this point, so as to have sufficient space for telegraphic and other apparatus.

"(11) What would be the limit of capacity of one single line tunnel, constructed according to the proposed conditions?

"Taking as a basis the quantity of air which will be provided, according to the project for ventilation, and the conditions that we have imposed, one single line tunnel will accommodate a daily average of twelve passenger and thirty goods trains without the air becoming saturated with noxious gases sufficiently to exercise any unfavorable influence on the respiratory organs of human beings. In this calculation we have assumed that the traffic will not exceed twenty hours per day, so that the tunnel will remain free for four hours. This will be useful both for the ventilation and for cooling the rock.

"IV. Miscellaneous.—(12) Besides answering the above questions, have the experts any remarks to make on the subject? (a) Considering that the mortar used in the masonry of the tunnel lining is one of the most important elements in keeping the whole construction in good order, we recommend that, immediately the works are commenced, experiments should be made to ascertain what are the ingredients and proportions which will best withstand a temperature of from 85° to 100° in dry and also in wet rock. (b) We have discussed the employment of ordinary locomotives for working the tunnel, and have said that there will be no difficulty in using them, provided the traffic does not exceed the limits given above. However, we should like to direct your attention to electric traction. In the last eighteen to twenty-four months this mode of traction has made such progress that the problem may be considered as settled.

"At the Liverpool elevated railway, which is six miles long, the trains carry 100 to 250 travelers safely and cheaply. The average number of passengers in twelve months was 6,000,000, the number of trains 108,000 and the number of train miles 620,000. At the City and South London the number of passengers was 6,000,000, number of trains 145,000 and the train miles 442,000. The service is carried on with perfect regularity. A new and very important underground railway will shortly be constructed in London, for which electric traction will be adopted. In America the Baltimore & Ohio Railway Company are now building electric locomotives for the transport of merchandise under the city of Baltimore. These locomotives are intended to draw trains weighing 400 tons, and also the engines of these trains. Electric traction would be peculiarly advantageous for the Simplon Tunnel. There will be sufficient hydraulic power at either end of the tunnel, the mechanical appliances necessary for the construction of the tunnel can be used for generating the electric current afterward, and the complication caused by the ventilation may be avoided. The electric locomotive could be placed at the head of the train without any loss of time during the inevitable stoppage. It is very probable that before the Simplon Tunnel can be opened for traffic further progress will be made with electric traction, but our personal experience of it justifies us in recommending it now. Not only has it the advantage of not infecting the air of the tunnel, but by its use the wear of the rails will be considerably diminished. On this point we may mention that at Arlberg, notwithstanding that there is no great traffic, the gas from the locomotives has had such a pernicious effect that the whole of the ironwork has had to be renewed after being only ten years in use. If even with electric traction it is still necessary to cool the air of the tunnel, the water conduit described above can continue to be used.

"In conclusion we wish to remark that, after having thoroughly examined all details of the project which has been presented, we are convinced that the construction and working of the Simplon Tunnel will present no special difficulties if the necessary measures of prudence and safety are observed. We believe that we have in this report answered all the questions which have been put to us, and we hold ourselves at your disposal for any additional information. Thanking you sincerely for the honor and confidence you have shown us, we are, etc.,

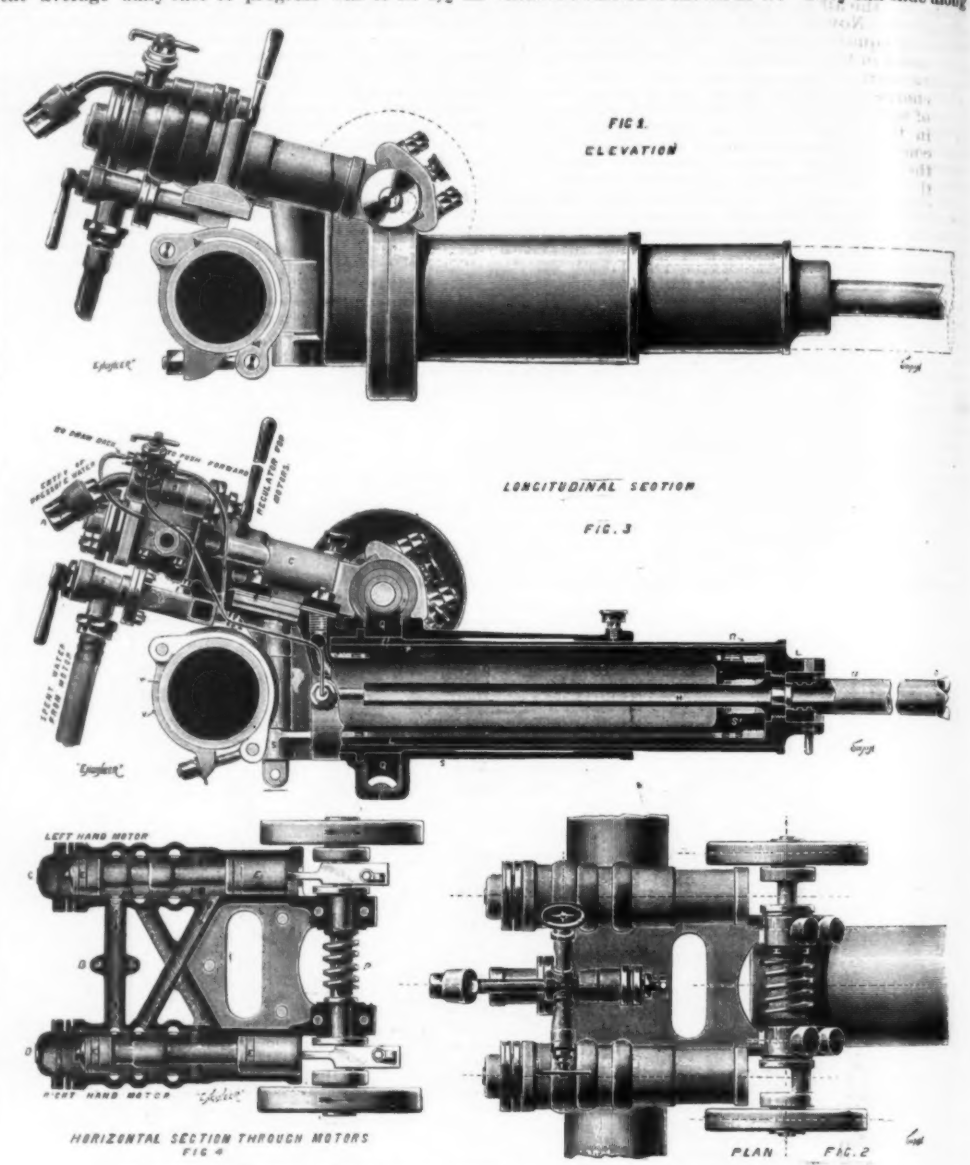
"(Signed) G. COLOMBO,
FRANCIS FOX,
Berne, July 19, 1894. C. J. WAGNER."

BRANDT'S ROCK DRILLS.

ENGLISH engineers, whether engaged in mining or tunnel construction, generally consider the percussive preferable to the rotary system for drilling in hard rock, and usually adopt compressed air as their motive power. It will, therefore, perhaps surprise many of the readers of the Engineer to see in the Simplon Tunnel report that Messrs. Brandt & Brandau, who have taken the contract for this great work, and who have already had considerable experience in tunnel making, have decided that they can pierce the rock which they expect to meet, more quickly, as well as more cheaply, with rotary drills than with percussive; and that they consider that hydraulic power will be more advantageous than compressed air.

Drills on the same principle were used by this firm on the west side of the Arlberg Tunnel in 1883. In this the average daily rate of progress was 18 ft. 4½ in. Tunnel excavation, and which was tried last year in the presence of the consulting engineers, at the works of the makers, Messrs. Sulzer Brothers, of Winterthur. Fig. 2 is a plan of the same; Fig. 3 a longitudinal section through the drill cylinder, showing one of the hydraulic motors in elevation; Fig. 4 a horizontal section through the motors, and Fig. 5 two drills at work.

In Figs. 3 and 4, the post or column on which the drills are carried is shown at W. They can slide along

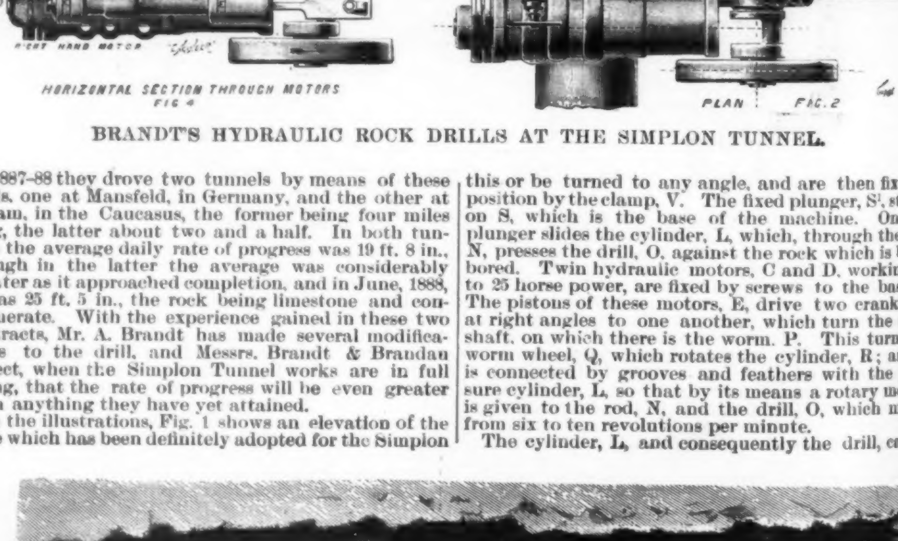


BRANDT'S HYDRAULIC ROCK DRILLS AT THE SIMPLON TUNNEL.

In 1887-88 they drove two tunnels by means of these drills, one at Mansfeld, in Germany, and the other at Suram, in the Caucasus, the former being four miles long, the latter about two and a half. In both tunnels the average daily rate of progress was 19 ft. 8 in., though in the latter the average was considerably greater as it approached completion, and in June, 1888, it was 25 ft. 5 in., the rock being limestone and conglomerate. With the experience gained in these two contracts, Mr. A. Brandt has made several modifications to the drill, and Messrs. Brandt & Brandau expect, when the Simplon Tunnel works are in full swing, that the rate of progress will be even greater than anything they have yet attained.

In the illustrations, Fig. 1 shows an elevation of the type which has been definitely adopted for the Simplon this or be turned to any angle, and are then fixed in position by the clamp, V. The fixed plunger, S', stands on S, which is the base of the machine. On this plunger slides the cylinder, L, which, through the rod, N, presses the drill, O, against the rock which is being bored. Twin hydraulic motors, C and D, working up to 25 horse power, are fixed by screws to the base, S. The pistons of these motors, E, drive two cranks, set at right angles to one another, which turn the same shaft, on which there is the worm, P. This turns the worm wheel, Q, which rotates the cylinder, R; and R is connected by grooves and feathers with the pressure cylinder, L, so that by its means a rotary motion is given to the rod, N, and the drill, O, which makes from six to ten revolutions per minute.

The cylinder, L, and consequently the drill, can be



THE BRANDT ROCK DRILL AT WORK.

moved forward 2 ft. 2½ in., until it assumes the position shown by dotted lines in Figs. 1 and 2. It is then moved back, and N, which consists of a series of pieces, connected by very quick-running screws, is lengthened. These pieces, as well as the drills, are made of drill steel 2⅜ in. diameter, with a ⅞ in. hole running through the center, to allow water to pass to the end of the drill. This is widened out to 2¾ in. diameter, and has three well-hardened saw-shaped teeth. When blunted, the drills are partly ground and partly milled. The column, W, which serves as support for one or more drilling machines, consists of a cylindrical tube, which by hydraulic pressure is very firmly fixed between the sides of the heading. With this object, there is a differential plunger with a piston at the open end of the tube. By means of a two-way cock the pressure water can be made to force the plunger either in or out, so that the column can be securely fixed or loosened immediately.

To work the machine, the column is first secured in position, the drills are then placed as may be desired, being turned by means of the universal joint in their base, and they are then clamped to the column by V. The movable end of the pressure main is then connected to A, and the motors started by means of the valve, B. By partially closing this valve, the speed of the motors may be regulated as desired. On the top is a two-way cock for moving the pressure cylinder, L, and consequently the drill, backward and forward, and there is also a regulator valve for regulating the pressure of the water from the main, so that the pressure on the drill may be increased or diminished according to the hardness of the rock. When this has been set, the advance of the drill is automatic.

The water which has served to drive the motors can still be used to wash out the bore hole, as it can be passed through the tube, H, into the hollow rod and the drill, where it serves to keep the teeth from being clogged by powdered stone, which it washes out through the space between the rod and the sides of the bore hole. The supply of this water is regulated by the cock, G, and all that is superfluous passes out through a hose, which conveys it to the drain. The working pressure varies from 375 lb. to 1,500 lb. on the square inch.

The makers claim that as the rotary drill has fewer moving parts than the percussive, it is less likely to get out of order, and that this advantage is increased by the fact of the movement being steadier and free from sudden jerks. While granting this, it is not so evident that with the Brandt drill all the advantages are on one side. Air mains are cheaper to construct and to maintain than water mains, and when a little air escapes it causes less inconvenience. The spent water from the hydraulic motors at the Simplon Tunnel flows out without assistance, but in the case of a mine it would all have to be pumped to the surface. Besides this, all the air from compressed air drills is useful in assisting the ventilation of the mine or heading; but when hydraulic motors are used the corresponding quantity of air has to be supplied by fans. It is true that at Simplon the supply of water is almost unlimited, and that is probably the reason why the consulting engineers have agreed with the contractors that the system they propose is the most suitable.—The Engineer.

VENTILATING FANS FOR THE SIMPLON TUNNEL.

IN the description which the Simplon Tunnel Company has given of the means by which it proposes to carry on the work, it has pointed out that on account of the great length of the tunnel, the arrangements for ventilation must be studied with exceptional care. Not only will air be required for the workmen and for clearing away the gases generated by the locomotives or in blasting, but the contractors rely on the constant circulation of large volumes of fresh air to lower the temperature in the center of the tunnel to a degree at which work can be carried on without inconvenience. The fact that the rock drills are driven by water instead of by compressed air renders an independent air supply even more imperative.

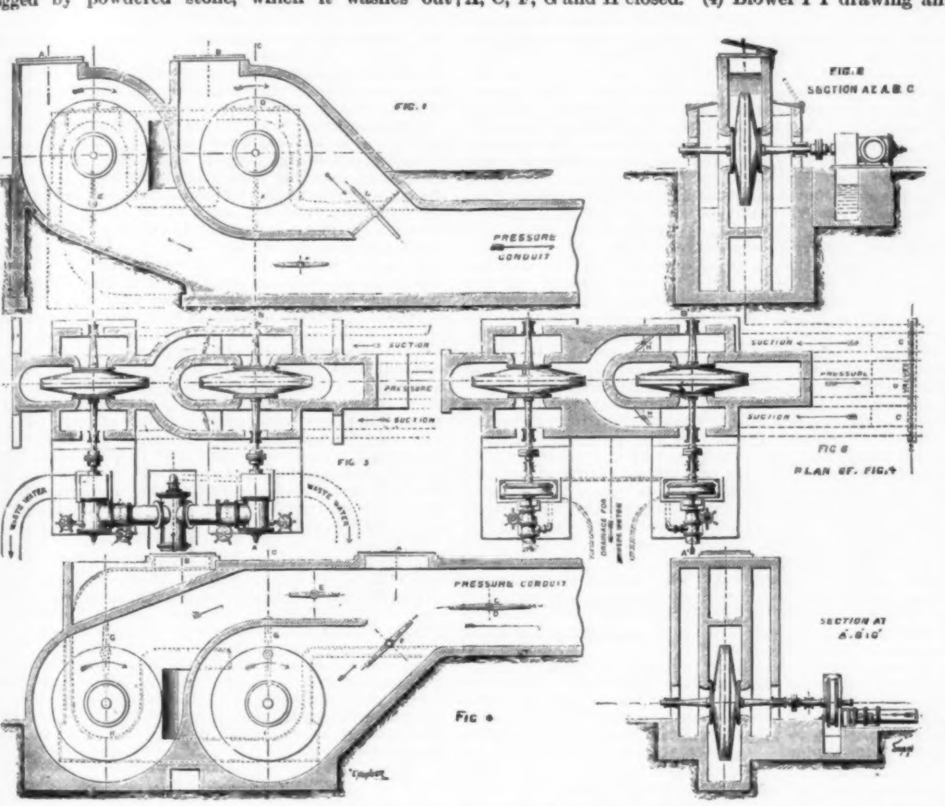
By referring to the illustrations it will be seen that there are two blowers, Figs. 1 and 4, each at the north and south ends; each blower being driven by a separate turbine to which it is coupled. The diameter of the revolving fan is 18 feet, and it is made of wrought iron plates with channel iron arms and a cast iron nave. At both ends of the tunnel the two blowers are placed one behind the other, with separate masonry flues, for the air coming to or going from the fans. The same letters refer to the same parts in all the figures.

Each blower can be used either to draw air from the tunnel or to force it in. They can be made to work together or separately, and in the former case they can be so arranged as to give either a double quantity of air or the same quantity but at double the pressure which would be produced by a single blower. Each blower will force into the tunnel or will draw out 1,750 cubic feet of air per second at a pressure equal to a column of water 9¾ inches high, so that they can either when joined give 3,500 cubic feet per second at the same pressure or 1,750 cubic feet at a pressure of 19½ inches.

These different arrangements are made by means of valves, which are turned by hand with a worm and worm wheel. The two suction flues, C, and the pressure flue, D, are connected with both the tunnel pipes, and on the south side the different positions of the valves are as follows:

(1) When air is being forced into the tunnel by I only, valves B, D, F and G are open, while A, C, E, G^1 and H are closed. (2) Blower I only working and drawing air from the tunnel. Valves A, C, F and G open; B, D, E, G^1 and H closed. (3) Blower I I only at work and forcing air. Valves B, D, E and G^1 open; A, C, F, G and H closed. (4) Blower I I drawing air. Valves A, C, E and G^1 open; B, D, F, G and H closed. (5) Both blowers working together and coupled so as to give double pressure. Valves B, D, F, G^1 and H open; A, C, E and G closed. The air which is drawn through the opening B passes through the two valves G^1 and enters blower I I on both sides. Leaving I I at half pressure, it goes through H H to either side of blower I, which it leaves at full pressure through the opening F, and thence through the flue D to the tunnel pipe. (6) Both blowers working together and coupled so as to give double quantity. Valves B, D, E, F, G and G^1 open; A, C and H closed. The air which enters through B passes on both sides of G and G^1 into the two blowers, from which it is forced through E and F respectively into the pressure conduit, D, and to the tunnel.

With a corresponding arrangement of valves, both blowers may be used to draw air from the tunnel through C, and in this case also they can be coupled, either for pressure or quantity. The general disposition of the blowers at the north end is similar to that at the south, though on account of the nature of the site there are some slight differences in the arrangement of the masonry. These blowers are being made by Messrs. Sulzer Brothers, of Winterthur. The erection at the site has not commenced, as the contractors are not ready for them; but one was tried last year in the presence of the consulting engineers, who expressed themselves satisfied that the blowers would do the required work.



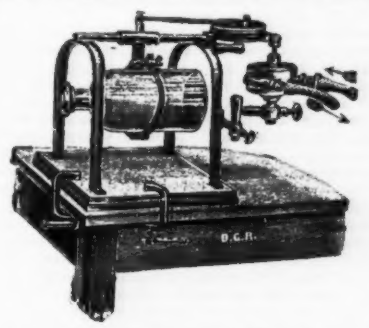
VENTILATING FANS FOR THE SIMPLON TUNNEL.

JAMES WATT, THE ENGINEER.

ALTHOUGH James Watt may not have helped actively in the application of steam power to ships, it is really to him and his inventions we have to look as the source from whence all the great modern improvements in ocean navigation have been derived. In him they found just the combination of qualities and the temperament which are required to enable a man to ascertain what is known of the forces of nature and their mode of operation, and to utilize and apply these in the most direct way for producing a required result. He formed that happy union of what is commonly called the "theoretical" with the "practical" man. For as there was no better practical mechanic than Watt in the country, so was there no more diligent student of the sciences related to the subjects of his work, or a more patient and thorough investigator of the principles or theories upon which it depended. He tested everything by experiment, and it is said that when asked an opinion of a novel invention or proposal, his reply invariably was, "Make a model." But having ascertained by experiments all he could learn of the facts connected with any subject he was never satisfied till these could be explained by some physical law with which they could be shown to accord. His mental attitude toward the great mechanical problems he took in hand was that of one engaged in a close and desperate struggle with Nature herself—questioning, cross examining, testing by experiments, attacking from all sides and refusing to give in till he had succeeded in wresting from her the particular secret he required to know. A favorite saying of his was, "Nature can be conquered if we can but find out her weak side." We thus see what are the qualities that are necessary to make a great engineer. They are mechanical skill and experience, scientific knowledge and capacity, great powers of observation and original investigation, energy, patience and untiring perseverance. There have been great engineers who have exhibited certain of these qualities in a very high degree, but none who possessed all of them together in such full measure and in such harmonious blending as we see in the case of Watt. No one man could otherwise, in a few years, have transformed such a rude and imperfect machine as the steam engine was when Watt first took hold of it into the most perfect instrument that the working capabilities of the time admitted. The proof of Watt's great powers as a mechanic and philosopher combined are to be found in the fact that he perfected in such a short time, within the limitations that were imposed by the quality of the materials and the workmen of the day, the greatest work that has been performed by any engineer of modern times. FRANCIS EDGAR.

APPARATUS FOR SHAKING BOTTLES.

THE apparatus which is shown in the figure is said to have the advantage that it can be set in motion by a small Rabe's turbine, worked by water and consuming 12 liters per minute, and will shake bottles con-



taining as much as 500 c. c. Larger instruments are also made.—C. Mauli.

OXIDIZED LINSEED OIL.*

By WALTER F. REID, F.I.C., F.C.S.

NEARLY the whole of the linseed oil which is manufactured in this country or imported into it is finally converted into the oxidized form; in fact, the large and growing consumption of this material is mainly due to the facility with which it absorbs oxygen from the air, and, in so doing, is changed from a liquid into a solid body. The paint which embellishes or disfigures our dwellings, the floorcloth or linoleum which covers our floors, and the pictures which adorn our walls—all owe whatever stability and cohesion they may possess to this oxidized modification of linseed oil.

In some industries, such as the manufacture of linoleum, and, to a small extent, in that of India rubber, the linseed oil is first oxidized and the solidified product is afterward mixed with other substances. In the majority of cases, however, the oil is used in its liquid state, as in paints and varnishes, and solidifies when exposed in a thin film to the action of the air.

Where the oil is oxidized as a preliminary process, two methods are employed on the large scale. In the first and oldest the oil is heated to temperatures varying from 350° F. to 500° F., with a small quantity of litharge or red lead. The operation is sometimes accelerated by blowing air through the oil, and samples are taken from time to time to test the progress of the oxidation. If a small portion of the oil becomes "stringy" when cooled and tested, the oxidation has reached a stage which is sufficient in some industries; but in others, such as the manufacture of printer's ink, the operation is pushed a little further and the surface of the oil is sometimes ignited. The product is a dark-colored, viscid mass of disagreeable odor and sufficiently fluid to take the shape of any vessel into which it is placed.

In the more modern process of oxidizing oil for the manufacture of linoleum, the linseed oil is first boiled with the usual quantity of litharge, or red lead, or a mixture of both, and the boiled oil is allowed to flow over sheets of a light cotton fabric technically known as "scrim," which are suspended vertically in sheds heated to 80° F. to 100° F. Every time the "scrim" is flooded by the oil, a film of oxidized oil is formed on each side, varying in thickness from $\frac{1}{5000}$ to $\frac{1}{1000}$ of an inch. When these accumulated films, now termed a "skin," reach a thickness of about ¼ inch they are cut down and ground between rollers preparatory to the next process. In this transverse section through a

* Read recently before the London Section, Society of Chemical Industry.—From the Journal of the Society.

"skin" you may be able to detect some of the daily films, and you will observe that the color deepens considerably toward the center. Oxidized oil made in this manner forms, as you will see by the sample shown, and amber-colored mass of considerable elasticity, but very deficient in tensile strength. It is heavier than water, while the original linseed oil is, as you are aware, much lighter. In this process of oxidation there is an increase of about 10 per cent. in weight; but the actual absorption of oxygen is greater, because considerable quantities of volatile substances, including much acrolein, are given off at the same time. The fiber of the cotton "scrim" has been much weakened, for linseed oil during oxidation has a powerful action not only upon textile fabrics, but also upon wood and even iron. The preliminary oxidation of the oil in this state is by no means complete. If ground between rollers and placed in a heap the solidified oil absorbs oxygen from the air with such avidity that ignition of the heap sometimes takes place. For making lineoleum the ground oxidized oil is heated with kauri gum and resin, forming an elastic, sticky cement, which, if dissolved in a suitable solvent, would form a varnish; it is, in fact, almost identical with the film left by a kauri varnish after evaporation of the solvent and oxidation of the oil contained in it. You will notice that this linoleum cement is somewhat darker in color than the oxidized oil; but seen in section by transmitted light, it appears much lighter than in bulk. It is tougher than the solidified oil which forms its main ingredient, although not quite so elastic.

The oxidized oil which you have seen in bulk is practically identical with the substance produced by the spontaneous oxidation of linseed oil when mixed with pigments to form paints. After observing the facts which I am about to bring before you, I carried out a number of experiments extending over many years, with films of both raw and boiled linseed oil alone and also mixed with various pigments. The results showed that the product obtained was almost identical with that which you see here.

Both in the case of paints and varnishes this solid, elastic substance has hitherto been regarded as the ultimate product of the oxidation of linseed oil when exposed to the air. Mulder, whose researches have thrown much light upon drying oils, and who termed it "linoxyn," says of it:

"It is the important basis of all linseed oil paints and the product of the drying of linseed oil."

Schaedler repeats this, and adds that linoxyn is probably the product of most drying oils. The same opinion is generally held with regard to varnishes containing linseed oil, and is well expressed by a technical writer in the following words:

"After an article has been varnished the process of solidification, to which we unphilosophically apply the term drying, is carried on by the absorption of oxygen gas from the surrounding atmosphere, and when the varnish is thoroughly hardened it has absorbed all the oxygen it is capable of, and the result is a beautiful, transparent glaze." Von Pettenkofer, again, who made many interesting researches on paints and varnishes and published a work on the restoration and preservation of pictures, assumes that the elastic film produced by the oxidation of linseed oil is permanent in its chemical properties.

If, however, we examine carefully the behavior of linseed oil for a period longer than that over which the investigations of these and other observers extended, we find that the properties of the oxidized oil are profoundly modified in the course of time; so profoundly, in fact, as almost to destroy the foundation upon which our theories on this subject have been based.

If a surface of pure oxidized linseed oil be exposed to the air for about two years, it becomes sticky and softens somewhat. In about three years, if the surface be vertical, part of it will run down as a semi-fluid mass, and in the course of five years a layer of oxidized oil 1 centimeter thick will be completely liquefied. You will see here the product which has resulted from the gradual oxidation of a "skin" of oxidized linseed oil which was, in 1878, identical in all its properties with the fresh one which I have just shown you. It is an extremely viscid, semi-fluid mass of a much darker color than the oxidized oil from which it is derived. Raw linseed oil produces a similar substance; but both the preliminary oxidation and subsequent liquefaction require a longer period of time than the boiled oil. The properties of this substance, which we may term superoxidized linseed oil, differ very materially from the initial linoxyn, and possess great interest in connection with nearly every industrial application of linseed oil. By studying it carefully we may find an explanation of many phenomena which have hitherto remained obscure. Like the solid oxidized oil, it is heavier than water; but it has also become to a considerable extent soluble in that liquid. In this property may be found the explanation of the necessity for the renewal, at comparatively short intervals, of all oil paint which is exposed to the weather, while similar paint protected from the rain will last very much longer.

Linoxyn is but slightly acted upon by alcohol, while the product of its subsequent oxidation is almost completely soluble in that solvent. Von Pettenkofer invented a process for the restoration of oil paintings by exposing them to the vapor of alcohol at ordinary temperatures; and in his work on the subject he ascribes the action of the alcohol to the restoration of the molecular contact of the pigments. He was unaware that alcohol was an almost perfect solvent for the medium by which these pigments were fixed. In this, as in other directions, there is a remarkable resemblance between linseed oil and India rubber. The first preparation of the India rubber, by warming a thin film of the liquid from which it is derived, much resembles the oxidation of the oil. Then follows what can only be regarded as an intermediate stage of solidity and elasticity, after which comes a final, or perhaps we had better say a further, stage of oxidation. During this stage the India rubber also becomes soluble in alcohol. There are further analogies, such as partial solubility in water, to dwell upon which would exceed the limits of this note.

In the facts which I have placed before you may be found the explanation of many phenomena which will be familiar to you. In old prints and books, for instance, you will frequently have noticed a brown stain on the paper adjoining the print, or on pages opposite dark woodcuts. From such stained paper I have extracted a substance identical with this superoxidized linseed oil. As the oil contained in the printer's ink liquefies, it is absorbed by and spreads through the paper, producing those stains which are too familiar to lovers of old books.

Again, some of you may have been vexed at the too rapid deterioration of articles made of patent leather, especially boots. The glossy surface of such leather is composed of a mixture of oxidized linseed oil and Prussian blue, and this will explain why the surface becomes sticky or cracks long before the leather itself shows signs of wear. So well known is this defect that dealers of repute refuse to hold themselves responsible for the wear of patent leather goods. American cloth, which is a cotton fabric dressed with a composition similar to that used on patent leather, acquires a disagreeable adhesiveness when packed away for a few months in contact with other articles.

One of the most useful articles in the chemist's laboratory is India rubber tubing. Many of us, no doubt, have met with samples of tubing which, while new, were apparently of excellent quality, soft and supple, although, perhaps, slightly deficient in elasticity. In about a year's time such tubing, should it contain solidified oil, will be unfit for use, while pure India rubber will show hardly any signs of decay. The India rubber itself will, of course, eventually become unserviceable; in fact, all elastic substances with which I am acquainted, except one, are very prone to decay. That one is the curious mineral elaterite, of which I have brought a specimen with me in the hope that it may be of some interest. This piece is from Derbyshire, and has been exposed in the open air for thirteen years without the least deterioration. You will observe that it possesses considerable elasticity under compression, although its tensile strength is not very great.

It is found in the carboniferous limestone impregnated with a dark brown mineral oil of the consistence of gas tar. The other substances which I have noticed associated with it are iron pyrites, galena and the sulphates of iron and lead. I believe that many years ago attempts were made to distill a mineral oil from this substance, but the progress of industrial chemistry has since been such that the problem has been reversed. A process for converting the heavier mineral oils into elaterite would enrich us with a substance which might find many useful technical applications.

Those of you who take pleasure in visiting a picture gallery—and who does not?—must have remarked with regret the condition of so many of the oil paintings. The colors of the pictures of comparatively modern date are far inferior to those of the frescoes on the walls of Pompeii or in the chambers of the Egyptian tombs, and it would be an insult to the memory of the artists to suppose that they ever laid on their colors in the somber shades which we now see. It has been supposed that some special virtue lay in the pigments used in Greece and Egypt; but analytical chemistry, together with the records which have been handed down to us, enables us to reproduce with accuracy almost any pigment known to the ancients. Aniline colors are of very recent origin, and we must look to the medium used for an explanation of the deterioration which has undoubtedly taken place. Two main causes have co-operated in producing the alterations which are but too evident. One is the liquefaction and darkening of the medium upon which the artist has relied to cement the particles of pigment to each other and to the canvas. The substance produced being extremely viscid, retains permanently any dust or dirt with which it may come into contact. The other cause of alteration in an oil painting is traceable to a more purely chemical action.

Linoxyn itself is an inert substance, difficult to dissolve and to bring into combination with other substances. Tho product of its further oxidation, however, has a strongly acid reaction and forms solid compounds with most pigments of a basic nature. With white lead, for instance, a solid compound is produced which, though very friable and brittle, is quite solid and prevents the liquefaction of any paint of which that pigment forms a substantial part. Those who have attentively examined the darker portions of pictures will have noticed that cracks and flaws are there much more frequent than in the lighter portions of the same pictures. Most of the dark-colored pigments are but slightly basic in their nature, and they require a very much larger proportion of oil than the lighter colors. While white lead gives a good paint with but one-eighth of its weight of linseed oil, ivory black cannot be used with less than its own weight of oil, and lampblack requires even a greater proportion. The larger the quantity of oil present, therefore, the less basic is the substance which alone is available for maintaining it in a solid condition. When lampblack, or any finely divided variety of carbon, is used as a pigment, the occluded oxygen in its pores has a most injurious effect on the consistence of the paint, and it is well known that such black paints have a great tendency to remain sticky or "tacky." I have known a manufacturer to prepare a special quick-drying oil for black paint, with the inevitable result that the paint was worse than before. This defect of black paint has frequently been attributed to the pigment alone. John Smith, who wrote a curious treatise on the art of painting about two centuries ago, says:

"In the substance of the color is contained a certain greasy fatness that is an enemy to drying, to remedy which, burning in the fire till it be red hot and cease to smoke will consume that fatness, and then it will dry much sooner."

This treatment would no doubt improve the drying qualities of the paint, because the oxygen contained in the pores of the carbon would be driven off at a red heat.

The surface to which oil paint is applied must necessarily exercise an important influence upon the conservation of the film. If it contain a basic substance or a carbonate, the effects of the liquefaction of the linoxyn may be partially neutralized. Miniatures painted in oil upon ivory no doubt owe their generally good state of preservation to the combination of some of the mineral constituents of the ivory with the organic acids, as these are generated during the oxidation of the oil.

Many other similar instances might be given; but I think, after what has been said, you will agree with me that it is a matter for deep regret that most of the talented artists of our generation are embodying the creations of their genius in a material which is anything but permanent, however pleasing its appearance may be for the moment.

The President said: Of course all dried rubber contained a certain amount of oxygen. He might say that many years ago he was in Gran Para, and had the opportunity of seeing the process of making India rubber as carried on by the Indians and half breeds who tapped the Seringa. That the process was not altogether one of oxidation was obvious from the fact that the finished rubber, though containing a certain amount of oxygen, was not equal in weight to the juice that had gone to make it. It was clear, therefore, that a considerable amount of moisture was given off in the process of coagulation. With respect to the remarkable capacity of oil for absorbing oxygen, he might mention a curious experience of his own. Some years ago he was consulted by a blanket manufacturer at Huddersfield as to the extraordinary way in which the blankets, after being drawn from the bleaching house, where they were treated by the fumes from burning sulphur, fell here and there into holes. He went carefully over the whole process, but for a time could get no clew to the mystery. Eventually, however, it was discovered that while the blankets were in the centrifugal machines after removal from the fulling mill, the engineers, in oiling the bearings, would sometimes inadvertently spatter some of the blankets with drops of oil, and when these blankets were afterward exposed to the sulphur fumes the oil brought about the rapid oxidation of the sulphurous acid, and so effected the tendering of the fabric.

Mr. W. F. Reid said that the non-increase in weight of India rubber sap by oxidation was due to the fact that the juice contained only a small portion of the active substance, just as linseed only contained a certain percentage of linseed oil; but if one could obtain the pure substance contained in juice in its liquid state, and treat it by heating, one could find out whether there was a sensible increase or not. He hardly thought there would be, seeing that the percentage of oxygen in India rubber was very minute. In fact, it was not a process of oxidation, but it might be one of polymerization. If linseed oil were heated in a closed vessel, it solidified, showing that internal molecular changes took place which were not due to oxidation. Possibly, it was so with India rubber. Mr. Ives had asked if the Egyptians did not use wax as a vehicle. He believed they did not, but the Greeks certainly did, and had a peculiar way of preparing it. They used punic wax, mixed with volatile oils as a medium. The wax was kneaded with sea water, and exposed to the light; and modern experiments proved that the punic wax so treated possessed qualities quite different from those of wax bleached in the sun without the use of salt water. He could not agree with Mr. Christy that linseed oil was doomed. It had many and increasing uses, and no doubt its defects would be neutralized by the methods of using it; as in the case of linoleum, in which a large percentage of ground cork was used, and this absorbed the liquid oxidation products of the linseed oil as they were generated. With regard to the petroleum varnish referred to by Mr. Christy, he would like to know if its basis was similar to the elaterite, of which he had shown specimens; if so, it might be a permanent varnish.

With regard to the blue pigment which had been referred to, he had derived his information from the article cited by Mr. Cresswell, which proved the value of the Society's Journal in gathering notes together that might otherwise be lost. As to petroleum, he hardly thought it necessary to turn it into a soap, as it was an excellent cleansing agent naturally. He had tried experiments on a small scale, not only with poppy oil, but with nut oil also. Both oxidized much more slowly than linseed, but both eventually liquefied, and Schaedler was quite right in saying that all drying oils possessed the same property, though they contained less linoxyn.

STAINED GLASS WINDOWS.

MR. LEWIS F. DAY delivered recently a lecture at the Royal Institution upon "Stained Glass Windows and Painted Glass," from the point of view of arts and craftsmanship, more especially the latter. He said that the making of glass is very ancient and that Sir John Lubbock had stated that glass beads were in use in the bronze age. Stained glass windows existed in Limoges in the year 979, and the ancient Greeks may have painted upon glass; if so, they did it but in a small way. Painting on glass was certainly known at the beginning of the twelfth century; the oldest in France was produced in 1108, and there are some windows in Canterbury Cathedral dating from 1174.

Stained glass in early days was in use only in the church. The difference between stained and painted glass is this: With stained glass painting is only resorted to to help out the design on the stained glass; in the other case stained glass is used to eke out the painting. There are cases in which the two methods are much blended. Stained glass is stained in bulk in the pot, and is technically termed "pot metal," and the color is not merely laid upon the surface of the glass. The different colors are given by various metallic oxides. In stained glass windows each piece is cut out of a separate piece of glass, and the design is built up by glazing, for the artist is not a painter, but a glazier. He makes a drawing first with charcoal, with the view of cutting out pieces of glass afterward to suit the design. In the earliest days the diamond was unknown; the cutting was done by drawing a red hot iron over the glass, and then applying a bending strain, whereby pieces of glass were obtained approximately of the form desired, and afterward they were brought more nearly into shape by rude mechanical means. Such was the method employed in the thirteenth century. The leads for holding the pieces of glass together are some of them drawing lines and some are not.

Glass may be painted upon with almost any medium as a vehicle; the vehicle is merely used to make the metallic oxides adhere to the glass, until they are burnt in by a fire hot enough to fuse them.

Pot metal colors, however, were alone used in the earlier times. Faces would be cut out of glass of a

pinkish color, and the drawing done upon them in brown, in the simplest and flattest manner. The pieces of glass are connected by bands of lead of the necessary cross section, and are soldered at the joints. A kind of putty is used to cause the glass to adhere to the lead, and it helps to give strength to the whole window, near the edges of which wires with projecting lengths are sometimes worked in here and there to help to connect the window with the stonework. Hence, the operations produce results resembling cloisonne work. They bear a resemblance to Byzantine enameling, only the design is in this case transparent. Therefore the finished work should be judged rather as a mosaic than as a painting.

After speaking of Arabian lattice work, he said that stained windows may be compared to jewelry, and the craftsmen in the earlier times had that idea in their heads, for glass was then a costly substance; the earliest specimens, indeed, bore such names as ruby, sapphire, emerald and so on. They did not think of obscuring the colors of the glass by painting upon them. The craftsman was, in fact, a glazier. Painting began with the era of figure drawing on glass. He projected upon the screen several representations of work in stained glass windows, which in the earliest times had a white and not a colored background. In small work in windows, he said, the blue rays "spread," and to the observer get mixed with the red, giving that objectionable hazy purple effect so common in French stained glass windows. The glasses used in the early windows were full of streaks and bubbles; no two specimens came out alike, and artistically they were not all that could be desired. The figures in thirteenth century windows were crude, rude and grotesque—a kind of bogies likely to frighten children.

PNEUMATIC STEEL FIREPROOF STORAGE FOR FLOUR MILL ELEVATORS.

THERE has recently been put into successful operation a plant in direct connection with the mill of the Northwestern Elevator and Milling Company at Toledo, O., which is described in Milling as follows: The engraving shown herewith will give a very fair idea as to the manner in which this plant is arranged. As will be observed, there are no elevators, conveyors, drag belts, etc., required for the purpose of transporting the grain. The elevator which delivers to the receiver in the mill is the old hoisting elevator originally used. Otherwise a suction spout might have been applied instead. All the machinery actually required is the blower, which is located on the top floor of the mill. Two tanks of 20,000 bushels capacity each have thus far been erected, and it is the intention of the Northwestern Company to build several more tanks this coming spring. Provisions have been made to erect altogether nine tanks. The receiver or vacuum chamber, A, is an airtight steel tank located on scales. A glass window shows the operator the height of the grain therein. There is a continuous feed device underneath the receiver, operated by means of a belt from a pulley on line shaft. The blast pipe, B, leading to point of discharge under the receiver is made tapering for the purpose of increasing the force of the air current. By means of a system of valves and branch lines, grain can be delivered to any tank or drawn from the tanks into the mill as well as to transfer from one tank to another. The blower, C, is started to run in a given direction when it is intended to transfer from receiver to tanks or to bins in the mill. Provisions are made by means of the twist belt to reverse the blower when it is intended to draw wheat from tanks to the receiver. The suction pipe, D, receives the grain from either tank and is provided with a mouth piece in order to facilitate a proper feeding of grain to the air current. When removing grain from the tanks the valve, a, is closed and the grain is led directly into the receiver. The air exhaust pipe, E, is many times the area of the receiving or discharge pipes in order to diminish the speed of the air current and prevent any grain from being carried over. All floating dust and chaff is drawn out by means of the pipe, E, and delivered through the spout, F, into a dust chamber, whereby a thorough aspiration is obtained.

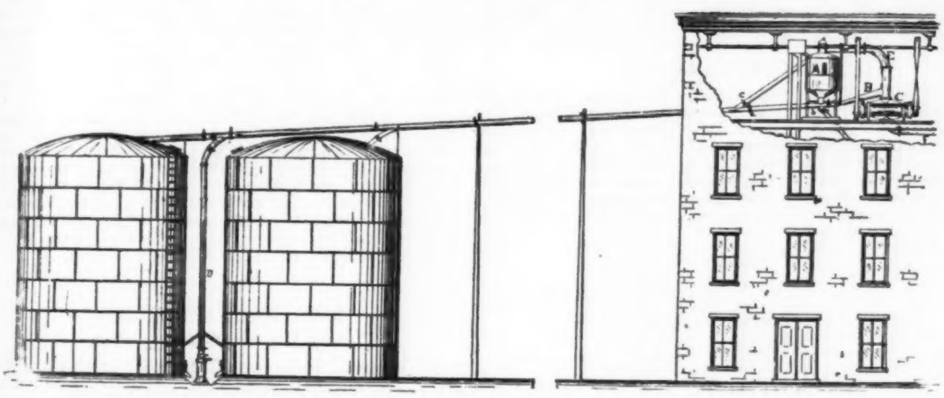
When wheat is to be delivered to bins in the mill, valves, b and c, are opened and valve, a, closed. When delivering to tanks, valve, a, is opened, valves b and c are closed. The valves in connection with the tanks are then opened or closed according to which tank is to receive the grain.

The mechanism thus applied is based on common sense principles, all complications being avoided. Steel is now so cheap that it is by odds the cheapest material that can be used for such purposes. This revolution would have been impossible ten years ago. For elevator buckets, conveyors, drags, and the whole list of mechanical expedients now employed, the power of nature in pneumatics is substituted.

It is claimed that with this plant one thousand bushels of grain can be handled in one hour and not to exceed eleven to twelve horse power will be consumed. The extreme vertical lift is 55 feet and the horizontal lift 200 feet. The consumption of power can be reduced accordingly as the distance of travel is made less.

There are a number of valuable points set forth in this style of elevator system. Grain may be held for months without the slightest deterioration. The cool temperature will prevent weevil from putting in its appearance even during the hottest of summer months. The writer is familiar with a case where corn that was wet and heated had been purchased, in fact the corn was fairly soaked, and was bought at a very cheap figure. It was subjected to a high current of air by means of which it was elevated 58 feet and discharged by blast into a car. After thus handling the corn the second time it was made marketable. The following is also a case on record: No. 2 and No. 3 wheat were mixed together in the same tank, and handled through the pipes back and forth several times until a large amount of dust and chaff was removed. After cooling and drying, the wheat passed as No. 2 with one per cent. premium. The large amount of cool air which is applied while the grain is thus being turned over will be the means of leaving it in much better condition for keeping. The miller has the satisfaction of knowing that he can keep his grain without fear of deterioration, heating or weevil. Another great advantage gained by this system of elevator is that the tanks are perfectly fireproof. In case of the mill burning there is no danger of fire or smoke injuring the grain. Besides, there is the great saving of insurance. It has long been conceded that lightning will never strike a steel tank, and every one must have noticed the partiality of lightning to granaries or elevators built of wood.

The plant here described is giving perfect satisfaction and millers interested will find it advisable to investigate it. The system is being introduced by the Smith Pneumatic Transfer and Storage Company, of Chicago.



PNEUMATIC STEEL FIREPROOF STORAGE FOR FLOUR MILL ELEVATORS.

MEDICINE THREE THOUSAND YEARS AGO.

THE recent discoveries concerning medical practice and ideas of the ancient Egyptians enable us to determine the condition of that science in the fourteenth and fifteenth centuries B. C. It is well known, moreover, that the papyri existing in different European libraries have furnished the material for a series of most remarkable works on the history of medicine. Professor Berthelot, to whom we already owe the masterly Introduction to the Chemistry of the Ancients, has lately published in the Journal des Savants some interesting observations in regard to the chemistry, mineralogy, and medicine of the ancient Egyptians.

The statements made by this eminent author, although of a purely scientific character, are so attractive that we feel sure our readers will appreciate being made acquainted with them.

Let us first observe that Egyptian physicians were celebrated in the orient of antiquity before the spreading of Grecian science; they are already mentioned in the Odyssey; Herodotus also speaks of them. Nobody being considered a prophet in his own country, the physicians of ancient Egypt contrived by very ingenious expedients to secure the respect which was due to their science. They simply dated the medical traditions back to the very origin of Egyptian civilization. According to these traditions, Athothis, son of Menes, and second king of Egypt, had been a physician, and the authorship of certain treatises on anatomy and medicine was attributed to him. Similar claims were made for Tosorthros, second monarch of the third dynasty, and Cheops. Other books were credited to Isis, Hermes, and Agathodaemon.

In order to enhance the authority of these books, romantic stories were told of their discovery. One of these medical works was said to have been found by miracle when the whole land was buried in darkness. The light of the moon shining upon the manuscript in the sanctuary of the goddess Tebmut caused its discovery, and the manuscript was placed in the treasury of King Cheops.

The medical papyri of Egypt, like the treatises of the middle ages, contain traditional remedies, based on empirical deductions not always to be despised, mystical prescriptions founded on the strangest analogies, and magical practices originated in most remote antiquity.

One of the most interesting papyri is that found by Mr. Ebers during his sojourn in Egypt in 1872. The antiquity and remarkable state of conservation of this work, the value of its contents, and the beauty of the writing give it especial prominence.

It is composed of 108 leaves, each containing from 20 to 22 lines. According to Ebers, it would date back to about 1553 to 1550 B. C., and would be the celebrated book designated by Clemens of Alexandria as the treatise "On Remedies."

Without stopping to discuss the truth of this affirmation, we would observe that the Ebers papyrus treats not only of medicaments, but of diseases of the internal organs, of the eyes, of women's diseases, etc. It is a kind of medical encyclopedia.

The papyrus in reality is a compilation of a large number of small treatises, some of which certainly are much older than the copy. The style and method of each are different. About 39 works are contained in the papyrus.

One of these treatises is devoted to the art of preparing medicaments for all parts of the human body. The author commences with the sacramental introduction: "I come from Heliopolis. . . . . I come from Sais, under the protection of the gods;" then follows an invocation of the gods: "O Isis, great magician! . . . . O Ka! O Osiris! protect me from the evil works of Typhon, from the demoniac and deadly fevers."

From the very beginning we meet a quantity of half mysterious and half real formulas which are characteristic of the sciences of those times. It may even be said that the Ebers papyrus is written in a more scientific style than other documents of the same period, as it contains fewer formulas of this kind.

After the introduction, which is only a sort of tribute paid to the customs of the times, the author gives definite receipts without comment. These prescriptions state the precise doses of medicaments used.

Among the ingredients employed in the preparation of the medicaments, we find: beer, honey, gum, figs, sebestens, different kinds of vegetable products, and a few mineral substances.

We have already mentioned that the papyrus contains 108 leaves, manifestly written by different authors. One part of the work treats merely of prescriptions, while at other places we find laudatory statements, bearing a strong resemblance to modern advertisements. Thus we read on leaf 46: "The god Ka himself has employed this remedy for his own troubles." At other places we are informed that the goddess Tefnut, the goddess Nut, or the goddess Isis had used certain medicaments for curing the headaches of the god Ka.

Some of the recipes are very curious and show that physicians of those times were gifted with vivid imaginations. The following samples will give an idea of this:

Shrimp's head; silure's skull, boiled in oil, for curing neuralgia; pig's teeth, ground; excrements of antelope and crocodile; lizard's blood, cat's uterus, brains of man or of tortoise.

It is to be observed that a considerable number of these prescriptions was used in the middle ages, and are preserved almost unaltered even nowadays with oriental nations and the superstitious peasants of Europe.

Several treatises are on special diseases. Diseases of the eye, being very common in Egypt, are discussed at considerable length, and curiously enough, this particular treatise is attributed not to some god, but to a semite of Byblos.

Women's diseases are also given special prominence, as well as medicaments for the teeth, the nose, the ear, the breast, the hair.

The following introduction is found in a treatise on the heart:

"Here commences the secret book of the physician. It comprises the knowledge of the heart, and all that appertains to it; it describes the vessels of the whole body. Its contents are of interest for any physician, priest, magician, when the operator places his fingers on the head and its contents, on the hands, the region of the heart, the arms, the legs, and especially when he feels the heart and applies his remedies on all the members."

This treatise is a kind of Egyptian anatomy, accompanied by one of the strangest pathological theories. A critical examination, however, is very difficult in view of the impossibility of comparing the medical science of Egypt and that of our times. The translation given for technical terms is uncertain, and comparisons can only be made where diseases of the visible parts of the body are concerned, such as diseases of the eyes, the nose, the limbs, the skin, etc.

It is certain, however, that in this medicine, the oldest that we know, all parts of animals were made use of. The head, the ear, the eyes, the liver, the brains, the teeth, the horns, the nails, the skin, the hairs, the testicles or vulva of the ass, the cow, the dog, as well as their blood, their fat, their milk, their bile, their excrements. In some recipes even man's brains and excrements are included.

Here is an example of the old Egyptian fashion of treating patients. A man suffers from amblyopy, that is weakness of sight. Two pig's eyes are crushed and in the liquid thus obtained honey, collyrium, etc., are dissolved. The most extraordinary thing about this treatment is that the solution was to be put in the patient's ear.

Honey was very frequently employed and was substantially a substitute for the sirup of sugar we employ nowadays. Plants and botanical products are essential in this therapeutics, as might be expected.

Oil, wine, beer, vinegar, gum, also often are ingredients of remedies and medicated beverages; beer is mentioned either as bitter or sweetened by sugar, its yeast and froth are also employed.

Figs, sebestens, dates, are extensively used, the latter on account of their juice, their wine, the flour and paste prepared from the dried fruits, and even the kernels. Similarly, the acanthus furnished its fruits, its resin, its paste, its thorns, its fibers, and its twigs. Myrrh, mastic, different kinds of resin, and opium were employed. Absinthe, aloe, cumin, coriander, anise, fennel and saffron are mentioned, also the sycamore, the cypress, the lotus, flax, juniper berries, henbane, and mandrake. It will be noted that there were very active substances among the medicaments of the Egyptians.

One of the most interesting vegetable compounds is the kyphi, or sacred perfume. It is prescribed in the Ebers papyrus for perfuming dwellings or clothes; the composition indicated comprises myrrh, juniper berries, incense, cypress, aloe wood, Asiatic calamus, mastic, styrax, etc., ten substances in all. This is the same number as the one in Dioscorides' formula, which is very similar to that of the papyrus. The work Isis and Osiris, attributed to Plutarch, mentions sixteen ingredients for the kyphi. Other authors cite twenty-eight and up to thirty constituents; it was, as it were, a real theriac. It is well known that there are inscrip-

tions relating to the kyphi in the temples of Edfu and Philae.

As to the mineral substances mentioned in the papyrus, their number is not considerable. Of the common metals, only copper and lead are used in the form of small pieces mixed with the excrements of dogs and cats. Copper slag is also mentioned.

No mention is found of either gold, silver, or tin. The name of mercury, however, occurs in the papyrus. According to Mr. Berthelot, arsenic already existed at that time, as well as marine salt and soda.

After all, if chemical medicine, which was brought into fashion by Paracelsus, has not been strongly represented in Egypt, all other medical systems have had their advocates in the land of the Pharaohs. Friends of sympathy cure, or faith cure, which has been just revived by the efforts of Baron Reichenbach and Mr. Carl du Prel, will doubtless find old, very old acquaintances in the faith in the curative power of animal excrements, as well as the adherents of Brown Sequard will recognize in the papyrus the faith in the testicles of bulls and asses, which has come very near working such a revolution in the medical science of the end of this century.—Dr. A. De Neuville, in Revue des Revues.

DRY BATTERIES.

By L. K. BOHM.

IN a certain sense, galvanic batteries may be distinguished as closed circuit batteries and open circuit batteries. Of the first type is required that they give a constant current for a certain length of time, because they are often used for several hours continually without interrupting the current. The typical battery of this kind is the Daniell cell; it consists of a glass jar in which rests a copper cylinder in a solution of sulphate of copper and a porous cup of clay which acts as a diaphragm, and contains diluted sulphuric acid, wherein is a circular zinc cylinder. Another well known cell which gives a still stronger current than the Daniell is the Grove battery. It contains a zinc cylinder in diluted sulphuric acid and in the porous cup is a thin platinum sheet in concentrated nitric acid. Another battery of this kind is the Bunsen, which is constructed like the Grove, but has carbon in place of the platinum sheet, because carbon is very cheap. These batteries give a constant current for quite a while, but the salt solutions and the acids are exhausted before long and then have to be renewed, and the zinc cylinders are gradually eaten up.

OPEN CIRCUIT BATTERIES.

The open circuit batteries on the contrary are quickly exhausted; they decrease in strength considerably if closed for a few minutes only, and they must rest for some time before they come up to the original strength again, therefore these batteries are used where current is needed for a few moments at a time, as, for instance, in connection with electric bells in houses, where, by touching the button, contact is made and a circuit is closed for a few moments only at a time, while the rest of the time the circuit is open; hence these batteries are termed open circuit batteries. The typical battery of this kind is the Leclanche cell, which consists of a glass jar containing a solution of sal ammoniac, in which is a zinc rod, and a porous cup containing a mixture of carbon and manganese dioxide and a carbon plate. The upper rim of the glass jar and of the porous cup has to be covered with paraffine or grease in order to prevent the creeping up of crystallized sal ammoniac, which would settle all over the glass jar. This battery has been extensively used for operating house and hotel annunciators, electric bells, domestic telegraphs, telephones, burglar alarms, electric clocks and in electric gas lighting, etc. As the above named uses indicate, the open circuit battery is employed principally in private residences and hotels, and if overturned by accident the sal ammoniac solution will ruin wooden fixtures, carpets, etc., and notably by this deficiency the attention of inventors was turned to the construction of batteries without solutions for open circuit work, that is, to dry batteries.

HISTORICAL DRY BATTERIES.

In the early days of electrical science it was believed that conducting liquids were absolutely necessary for constructing a galvanic battery. Then the crude dry cells were invented, which seemed to prove that no liquids need to be in a galvanic cell. However, moisture at least is necessary for making a galvanic cell operative. This has been proved by Ermann,* who placed a dry battery in an artificially dried space and observed that there was no electricity then.

The first dry cell was constructed by Behrens,† who used zinc and copper plates, which were separated by gold paper impregnated with table salt. De Luc‡ employed tin, silver and writing paper. Zamboni§ used artificial silver, paper and manganese dioxide. In those days a dry cell was often constructed of round pieces of paper, which were covered on one side with artificial gold (copper and zinc) and on the other with artificial silver (zinc and tin). The small diameter of these leaves made it possible that thousands of them could be used in a varnished tube, so that a pretty strong battery was obtained. Binding posts were provided at the ends of the tube, so as to allow the connection of the battery for work.

These crude dry batteries showed plainly the advantages of them in comparison with the wet cells. The absence of solutions in them guarantees absolute cleanliness; glass jars which easily break are not necessary; the cleaning and renewing of the zincs and the refreshing of the solutions is dispensed with, which renders the dry battery cheaper and more pleasant in use, and prevents disagreeable interruptions while the same are in operation. Although quite a number of dry batteries have been constructed within the last ten years by various inventors, still the dry cell has not received that attention by inventors which has been displayed in other branches of electrical science, and which this subject really deserves.

* Ermann, Gilb. Ann., xxv., 1.
† Behrens, Gilb. Ann., xviii., 1.
‡ De Luc, Gilb. Ann., xlix., 100.
§ Zamboni, Gilb. Ann., xlix., li.—lx., 182.

MODERN DRY BATTERIES.

In the modern dry batteries, zinc is generally employed as one electrode, and it is advisable to provide the zinc in the form of a cylindrical case, and to mount the other parts of the cell therein so that the glass jar is dispensed with. In its plainest form the modern dry battery consists of the zinc case, A, which acts as the

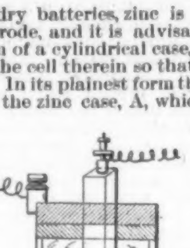


FIG. 1.—PLAIN FORM OF BATTERY.

zinc rod in a wet galvanic battery and is provided at the top with a binding post to which a wire can be attached, a carbon plate, B, which is generally mounted in the center of the zinc case without touching its bottom, and which is provided with a second binding post for attaching the second wire; a porous diaphragm or cylinder, D, between the zinc case and the carbon, made usually of paraffine or wax paper; an excitant, C, around the carbon plate and in the diaphragm cylinder and a seal on the top of wax, pitch or the like. The excitant may contain any salts which are used in wet batteries.

Thus it is plainly seen that every one can construct a dry cell for himself; the zinc cases and the carbons are found in the market and only the excitant has to be prepared. The excitants, whose composition is often a trade secret, are generally prepared in a pasty condition. Quite a number of dry batteries have been put on the market within the last decade and some of them will be described further down, when at the same time the components of the excitants will be given. Among the dry batteries which are on the market may be mentioned those of Dr. Gassner, Burndey, Bryan, Koller, Hellesen, Crosby, Hussey, Hewett and "The Mesco" of Harry T. Johnson.

HELLESEN'S BATTERY.

Although there is hardly any evolution of gas in dry batteries, still some gas may be formed, and in a hermetically closed battery these gases may force their way through some weak point or even injure the battery, therefore in Hellesen's construction little openings are provided in the top and above the active substances for allowing such gases to escape. Hellesen's battery consists of an outer receptacle, A, and an inner

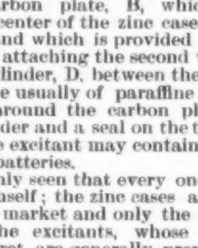


FIG. 2.—HELLESEN BATTERY.

receptacle, B, of zinc, the carbon, C, which is surrounded by a bag, H, wherein a paste is contained of di-polarizing substances; the space between the bag and the inner walls of B is filled up by a thick, slimy matter, containing the electrolyte, G, which causes the electrical excitation. Above the bag a layer, E, of plaster of Paris, or the like, is put in, and on the top is a layer of pitch. The space between the inner and outer receptacle contains sawdust or slag wool. The inner case, B, has two small air holes, a, in the portion where the plaster of Paris is.

The outer receptacle, A, has two small air holes, d, near the bottom. Any gases arising in the electrolyte, G, will pass through this mass, through the plaster of Paris, and leave through the hole, a, going through the sawdust or slag wool, and will pass out through the little holes. The carbon is provided at the top with a metal head, C, in form of a binding post, and the inner receptacle, B, is provided with a wire or binding post, which passes through the pitch, so that the current can be taken off.

BRYAN'S BATTERY.

Bryan has invented a battery for especial use in connection with electric belts. It consists of a semi-cylindrical zinc case, A, which is flat on the inner sur-

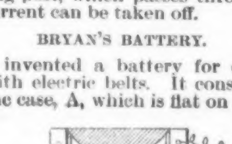


FIG. 3.—BRYAN BATTERY.

face, so that it can be fastened on the belt, a carbon plate, B, and an excitant, C, enveloping the carbon plate, B, inside of the case, A. A strip of paraffin paper insulates the carbon from the zinc. The excitant consists of sulphate of iron, six parts, bisulphate of mercury, one part, and sulphate of calcium, five parts, all by measure. Water is added to this mixture until the whole is plastic; it dries out in time and hardens. The sulphate of calcium acts merely as a body for the active ingredients of the excitant. The compound forming the excitant may be filled into the case while in a plastic condition. The top through which the excitant is introduced is sealed with wax.

KOLLER'S BATTERY.

In Koller's dry battery the excitant consists of plates of exciting material in a gelatinous consistency; the diaphragms in the cell are made of perforated sheets of waterproof insulating material, for instance, gutta percha paper, paraffin paper or wax paper. In order to prepare these plates agar-agar is boiled in sixteen to thirty times its weight of water until its structure is lost, when six parts of sugar sirup may be added to prevent the drying and shrinking. The mass is evaporated to a desired density, and before it solidifies metallic salts are stirred in there in dry form or as concentrated solution; these salts give the electric excitation in these batteries.

Any salts which may be used in a galvanic battery can be employed, except those which prevent agar-agar from coagulation. Sulphate of copper, for instance, will prevent the coagulation if too long in contact with the liquid agar mass. The amount of salts stirred in the agar mass is the same as would be used in a solution for this respective size in a wet battery. The pasty or solid mass, with the excitant salts, are cast into blocks, these blocks are cut into plates, which are inserted between the plates of the cell, the diaphragms are mounted so that the perforation of one diaphragm stands against the full part of the other. First is the zinc plate, then an agar plate containing sulphate of zinc; then follow two diaphragms, with space between them; then comes an agar plate containing sulphate of copper, then comes a copper plate. The copper and zinc plates are provided with binding posts so that the current can be taken off.

THE EFFICIENCY OF DRY CELLS.

The time which a dry battery will last depends upon the work it is to perform. For ordinary call bell or burglar alarm service it will last from one to two years. It is asserted that a dry battery rang an electric bell for over two hundred hours without interruption, a result which can hardly be obtained by the use of a Leclanche battery. A primary clock may be driven by a dry battery for over half a year. A primary clock connected with a secondary clock can be driven by three batteries for over nine months without being stopped for a moment. The electromotive force of dry batteries varies from 1·30 to 1·50 volts. Prof. Eric Gerard, at the Electro Technical Institute in Liege, Belgium, found 1·44 volts E. M. F. and 0·32 ohm internal resistance. The amperage varies according to size; some show six to eight amperes. The dry batteries are manufactured in various sizes. The outside dimensions of the most used sizes are, height 4¼ to 7⅜ inches, and the diameter is from 2⅞ to 7⅜ inches. For working bells a small cell will answer, while for telephone service a cell 7⅜ inches high and 4⅞ inches wide is generally employed.—The Electrical World.

THE MAGNETOMETER.*

By HENRY WILDE, F.R.S.

IT is not a little remarkable that, in this age of active experimental research, there should be any doubt as to the influence of temperature on the magnetic power of iron and other magnetic substances; yet from the seventeenth century to the present time the most discordant opinions have prevailed on this subject. Barlow, in the year 1822, found that the magnetic power of bars of iron which he experimented upon, as measured by the deflections of a compass needle, increased with the temperature up to a dull red heat, at which it was the strongest; but at a bright red heat all magnetic action of the iron suddenly disappeared.† Scoresby, Christie and others have also noted a similar increase in the magnetic power of iron with increase of temperature when measured by the same means. Faraday, on the other hand, described experiments to show that the magnetic power of iron diminished with increase of temperature. He also found that iron at a bright red heat was not entirely insensible to the action of large magnetizing forces.

More recently Rowland‡ and Hopkinson,§ by the employment of electro-dynamic methods and the needle indications of Barlow, have also found an increase in the magnetic power of iron with increase of temperature.

These experimenters were, however, the first to recognize that the apparent increase of the magnetic power of iron up to the dull red heat only held good for small magnetizing forces, and, further, they found with Faraday that the power diminished for large magnetizing forces with ascending temperatures. Rowland extended his observations to the magnetization of nickel and cobalt, and found that the magnetic behavior of these metals with increase of temperature was the same as he had observed in iron.

Experiments have also recently been made by Rucker on the effects of temperature on the natural magnet (magnetite), and he has found that the magnetic power of this mineral apparently increases with ascending temperature. A later pronouncement on this subject was made by the president of the Royal Society (Sir G. G. Stokes) in the year 1890, in the course of his anniversary address, in which he stated that it was generally believed that the susceptibility or magnetization of iron decreased with the temperature, but, on the contrary, it had been recently found that the susceptibility was enormously increased with ascending temperatures.‖ This generalization was afterward limited, through my representations, to the action of small magnetizing forces.¶

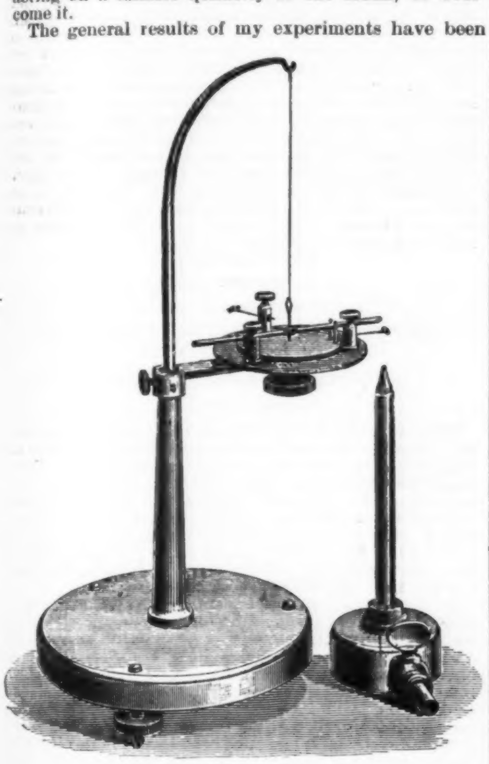
* Read before the Manchester Literary and Philosophical Society. Received October 2, 1894.
† Phil. Trans., 1822, p. 117.
‡ Phil. Mag., 1874, vol. lxviii, p. 321.
§ Phil. Trans., A, 1889, vol. clxxx, p. 443.
‖ Nature, December 11, 1890.
¶ Proc. Roy. Soc., December 1, 1890.

In my paper on "The Unsymmetrical Distribution of Terrestrial Magnetism,"* it was shown that by heating small surfaces of the thin sheet iron covering the ocean areas of the mapped globe, strong polarity was induced at the junction of the heated parts, just as when the magnetic continuity of the iron was interrupted by cutting through the same parts of the iron in an equatorial direction. Although this experiment appeared to me to demonstrate conclusively that the magnetic power of iron was reduced at comparatively low temperatures and with small magnetizing forces, yet, from the contradictory results which had been obtained by other experimenters, directly opposite conclusions as to the magnetic intensities of the land and ocean areas respectively might, with some show of reason, be drawn from those which I had arrived at. The important bearing which the influence of temperature has upon the phenomena of terrestrial magnetism induced me to undertake an investigation into the causes of the conflicting results hitherto obtained, with the hope also that I might be able to extend still further our knowledge of magnetic substances.

The results of my experiments, which are embodied in a paper read before the Royal Society,† confirm the general law of the diminution of the magnetization of magnetic substances with increase of temperature for small as well as for large magnetizing forces. I have also demonstrated in this paper that the apparent increase of the magnetic power of heated iron, magnetite and nickel is so small as to be a negligible quantity in general magnetic phenomena and terrestrial magnetism, and is due to a surface resistance of these substances which disappears: (1) On the application of heat; (2) by the action of strong magnetizing forces; (3) by diminishing the mass of the magnetic substance acted upon by the magnetizing force.

I have further shown that the surface resistance of cobalt at normal temperatures is so great as to require a tractive force equal to 373 pounds per square inch, acting on a minute quantity of the metal, to overcome it.

The general results of my experiments have been



THE MAGNETOMETER.

confirmed by M. P. Curie, in two able papers in the Comptes Rendus of the French Academy for April and May of the present year. M. Curie also agrees with my conclusion that the apparent increase of the magnetization of iron, magnetite and nickel is anomalous, and masks the principal phenomena of the decrease of magnetic power with ascending temperatures. M. Curie has extended his observations to the magnetic behavior of gaseous oxygen, and has found with Prof. Dewar, when experimenting with this element in a liquid state, a decrease of power with increase of temperature.

The general law of the diminution of the magnetization of all known magnetic substances with increasing temperatures is now completely established.

In connection with this brief summary of experiments on the influence of temperature on magnetic substances, I would direct attention to the close analogy, if not an actual relation, which subsists between the anomalous surface resistance of cold iron to magnetization and its anomalous property of resisting chemical action. Schonbein and Faraday have shown that bright iron wire, slightly oxidized by heat, is quite insensible to the action of strong nitric acid.‡ Not only is there no reaction under these conditions, but the oxidized wire has the property of inducing voltaic passivity in a number of pieces of bright iron wire by simple contact with them when immersed in the acid. Further, a passive bright wire has the property of inducing the passive condition in other pieces of ordinary bright iron wire.

It is admitted on all hands that this anomalous voltaic condition of iron is a surface resistance, as it disappears (1) by abrasion; (2) by the action of dilute nitric acid; and (3) by the application of heat to the wire.

To affirm, therefore, as a general property of iron, that its magnetic power increases with the temperature, is as irrational as to maintain that iron throughout its substance is, like gold and platinum, insensible to the action of strong nitric acid.

For demonstrating the influence of temperature on magnetic substances, I have devised a magnetometer which is shown in the accompanying figure.

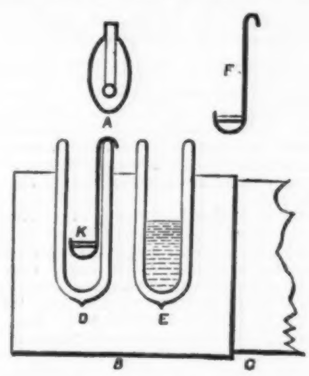
The instrument consists of a declination needle freely suspended from a double fiber of untwisted silk over a disk of brass. One end of the needle is thickly covered with spun silk to prevent the weakening of its magnetism by close proximity to the heated substance under examination. The excursions of the needle are limited in both directions by pins inserted a little distance apart on a diameter near the edge of the disk. The disk is pivoted on the end of an arm, to which it can be clamped firmly by means of a milled screw when the needle is drawn out of the magnetic meridian. Three binding screws are mounted at equal distances from each other round the circumference of a circular table, which has an independent movement round the disk. The magnetic substances are held in loops of platinum wire fixed by the binding screws to the table, and the properties of the specimens can be examined in succession.

The action of the instrument is as follows: The needle is drawn out of the magnetic meridian from 15° to 20° by turning the disk on its axis. The magnetic substance is then brought round toward the needle until equilibrium is established between its magnetism and the horizontal component of the earth's magnetism. The magnetic substance is heated by a small gas flame from below; when the needle recedes from heated iron, magnetite and nickel, and advances again when the source of heat is removed; thereby indicating a decrease of magnetic power for these substances. On the other hand, the needle advances toward cobalt when heated, and recedes when the metal is cooled by reason of its enormous surface resistance, which only disappears, as I have said, under the action of powerful magnetizing forces.—The Electrical Review.

* Proc. Roy. Soc., January 22, 1891.
† Proc. Roy. Soc., June 11, 1891.
‡ Phil. Mag., 1836, vol. ix., pp. 53-65.

CHEMICAL ACTION AT LOW TEMPERATURES.

PROFESSOR DEWAR, in a recent lecture at the Royal Institution, to show the great extent to which chemical action is prevented at low temperatures, placed a spoon containing burning sulphur in liquid oxygen; it continued to burn for a short time, then was extinguished by the cold, and a white emulsion of solid particles of solid sulphurous acid was left in the liquid. He then described, with illustrations, the



nature of the phenomena of phosphorescence and fluorescence, and explained the principle of Becquerel's phosphoroscope; he also showed that a board covered with commercial luminous paint, when shining in the dark after exposure to strong light, could have its luminosity stimulated by heat, which in his case was applied by contact with a hot flat iron. When phosphorescing bodies are greatly cooled they become dim, and conserve their power of phosphorescing, but begin to emit light again when they are allowed to become warmer. The blue and ultraviolet rays are those which chiefly set up these luminous phenomena, and the light afterward emitted by the body acted upon is always of lower refrangibility than that which produced the excitation. He showed that the red rays of the spectrum will undo the phosphorescent effect set up by the violet rays, and cause the substance to cease to shine in the dark.

Many bodies, he said, which have not the power of phosphorescing or fluorescing at normal temperatures gain it at excessively low temperatures, and he had the advantage that every substance he used became solid at the temperatures which he employed. He then performed a series of experiments in which the substance was first briefly exposed to a strong white light, then inserted into liquid air or oxygen, then exposed momentarily to the strong light again, and afterward quickly exhibited in the darkened theater. In this way he showed the brief phosphorescence set up in a linen shirt collar, silk, a feather, a white flower, an egg shell, sulphate of quinine, acetic acid a paraffin candle, ivory and several platinocyanides. The phosphorescence of the platinocyanide salts was exceptionally strong.

He stated that, in conjunction with Captain Abney, he had been working at the subject of photographic action upon gelatine sensitive films at low temperatures. He exposed some gelatine chloride paper close to the condenser of the electric lamp, all the time painting liquid air in a tuft of cotton wool upon one part of the paper; the part thus cooled remained white, while all the rest of the paper darkened. It was the same with short exposures, and subsequent immersion of the paper in a chemical developer. After treating films to such a low temperature, 20 per cent. of the original sensitiveness remained, which was an unexpectedly large proportion under the circumstances.

In farther experiments it was desirable, he said, to exactly determine the amount of sensitiveness at different temperatures, with the view of obtaining a curve which possibly might point in the direction of —274 degrees C., the absolute zero of temperature. The question he thought is how can chemical action—if it be chemical action—take place at such exceedingly low temperatures, especially as no water can be present to favor the production of chemical action.

In their experiments with gelatine plates an incandescent lamp, A, was fixed five or six feet above the box, B, which was blackened inside, and had a sliding door pulling out at C. Two vacuum jacketed glass vessels, D and E, dipped into the box, so that the light from A should equally illumine the interiors of both vessels. D, was full of common air at the ordinary temperature and E partly filled with liquid air. Two ladle-like appliances, K F, each supported a photographic plate, covered with an opaque screen with a hole in it, the hole acting as a window. In this way they were able to make comparative experiments without the light passing through the glass sides of the jacketed vessels. The exposures were of the same length and for the same time and made after the plate in F had reached the low temperature of the liquid air. In all cases the photographic image of the window was much denser upon the plate exposed at normal temperature.

Among the figures given by Professor Dewar at the lecture were the following:

	Percentage.	
	Heat.	Light.
Candle, Oil, Gas	98	2
Vacuum tube	97	3
Incandescent lamp	95	5
Arc lamp	90	10
Magnesium lamp	85	15
Sun	70	30
Cuban firefly (glowworm)	1?	99

THERMAL TRANSPARENCY.

Amount of heat transmitted through a cylindrical glass vacuum vessel containing the following liquids:

	Colza lamp radiation.
Chloroform	1·0
Carbon bisulphide	1·6
Liquid oxygen	0·9
Liquid nitrous oxide	0·93
Liquid ethylene	0·60
Ether	0·50

[FROM NATURE.]

ARGON, THE NEW CONSTITUENT OF THE ATMOSPHERE.*

VIII. SEPARATION OF ARGON ON A LARGE SCALE.

To prepare argon on a large scale, air is freed from oxygen by means of red hot copper. The residue is then passed from a gasholder through a combustion tube, heated in a furnace, and containing copper, in order to remove all traces of oxygen; the issuing gas is then dried by passage over soda lime and phosphorus pentoxide, after passage through a small U tube containing sulphuric acid, to indicate the rate of flow. It then enters a combustion tube packed tightly with magnesium turnings, and heated to redness in a second furnace. From this tube it passes through a second index tube, and enters a small gasholder capable of containing 3 or 4 liters. A single tube of magnesium will absorb from 7 to 8 liters of nitrogen. The temperature must be nearly that of the fusion of the glass, and the current of gas must be carefully regulated, else the heat developed by the union of the magnesium with nitrogen will fuse the tube.

Having collected the residue from 100 or 150 liters of atmospheric nitrogen, which may amount to 4 or 5 liters, it is transferred to a small gasholder connected with a small apparatus, whereby, by means of a species of self-acting Sprengel's pump, the gas is caused to circulate through a tube half filled with copper and half with copper oxide; it then traverses a tube half filled with soda lime and half with phosphorus pentoxide; it then passes a reservoir of about 300 c. c. capacity, from which, by raising a mercury reservoir, it can be expelled into a small gasholder. Next it passes into a tube containing magnesium turnings heated to bright redness. The gas is thus freed from any possible contamination with oxygen, hydrogen, or hydrocarbons, and nitrogen is gradually absorbed. As the amount of gas in the tubes and reservoir diminishes in volume, it draws supplies from the gasholder, and finally, the circulating system is full of argon in a pure state. The circulating system of tubes is connected with a mercury pump, so that, in changing the magnesium tube, no gas may be lost. Before ceasing to heat the magnesium tube, the system is pumped empty, and the collected gas is restored to the gasholder; finally all the argon is transferred from the mercury reservoir to the second small gasholder, which should preferably be filled with water saturated with argon, so as to prevent contamination from oxygen or nitrogen; or, if preferred, a mercury gasholder may be employed. The complete removal of nitrogen from argon is very slow toward the end, but circulation for a couple of days usually effects it.

The principal objection to the oxygen method of isolating argon, as hitherto described, is the extreme slowness of the operation. In extending the scale we had the great advantage of the advice of Mr. Crookes, who not long since called attention to the flame rising from platinum terminals, which convey a high tension alternating electric discharge, and pointed out its dependence upon combustion of the nitrogen and oxygen of the air.† The plant consists of a De Meritens alternator, actuated by a gas engine, and the currents are

* Abstract of a paper by Lord Rayleigh, Sec. R.S., and Prof. William Ramsay, F.R.S., read before the Royal Society, at a special meeting, on January 31.
Continued from SUPPLEMENT, No. 1000, page 15988.
† Chemical News, vol. lxv., p. 301, 1892.

transformed to a high potential by means of a Ruhmkorff or other suitable induction coil. The highest rate of absorption of the mixed gases yet attained is 3 liters per hour, about 3,000 times that of Cavendish. It is necessary to keep the apparatus cool, and from this and other causes a good many difficulties have been encountered.

In one experiment of this kind, the total air let in after seven days' working amounted to 7925 c. c., and of oxygen (prepared from chlorate of potash) 9137 c. c. On the eighth and ninth days oxygen alone was added, of which about 500 c. c. was consumed, while there remained about 700 c. c. in the flask. Hence the proportion in the air and oxygen combined was as 79:96. The progress of the removal of the nitrogen was examined from time to time with the spectroscope, and became ultimately very slow. At last the yellow line disappeared, the contraction having apparently stopped for two hours. It is worthy of notice that, with the removal of the nitrogen, the arc discharge changes greatly in appearance, becoming narrower and blue rather than greenish is color.

The final treatment of the residual 700 c. c. of gas was on the model of the small scale operations already described. Oxygen or hydrogen could be supplied at pleasure from an electrolytic apparatus, but in no way could the volume be reduced below 65 c. c. This residue refused oxidation, and showed no trace of the yellow line of nitrogen, even under favorable conditions.

When the gas stood for some days over water, the nitrogen line reasserted itself in the spectrum, and many hours' sparking with a little oxygen was required again to get rid of it. Intentional additions of air to gas free from nitrogen showed that about 1½ per cent. was clearly, and about 3 per cent. was conspicuously visible. About the same numbers apply to the visibility of nitrogen in oxygen when sparked under these conditions, that is, at amospheric pressure, and with a jar connected to the secondary terminals.

IX. DENSITY OF ARGON PREPARED BY MEANS OF OXYGEN.

A first estimate of the density of argon prepared by the oxygen method was founded upon the data already recorded respecting the volume present in air, on the assumption that the accurately known densities of atmospheric and chemical nitrogen differ on account of the presence of argon in the former, and that during the treatment with oxygen nothing is oxidized except nitrogen. Thus, if

D = density of chemical nitrogen.
D′ = " atmospheric nitrogen,
d = " argon,
a = proportional volume of argon in atmospheric nitrogen,

the law of mixtures gives

$$ad + (1 - a)\,D = D'$$

or

$$d = D + (D' - D)\,/\,a.$$

In this formula D′ − D and a are both small, but they are known with fair accuracy. From the data already given

$$a = \frac{65}{0{\cdot}79 \times 7925}$$

whence if (on an arbitrary scale of reckoning) D = 2·2990, D′ = 2·3102, we find d = 3·378. Thus if N_2 be 14, or O_2 be 16, the density of argon is 20·6.

A direct determination by weighing is desirable, but hitherto it has not been feasible to collect by this means sufficient to fill the large globe employed for other gases. A mixture of about 400 c. c. of argon with pure oxygen, however, gave the weight 2·7315, 0·1045 in excess of the weight of oxygen, viz , 2·6270. Thus, if a be the ratio of the volume of argon to the whole volume, the number for argon will be

$$2{\cdot}6270 + 0{\cdot}1045\,/\,a.$$

The value of a, being involved only in the excess of weight above that of oxygen, does not require to be known very accurately. Sufficiently concordant analyses by two methods gave a = 0·1845; whence for the weight of the gas we get 3·193, so that, if O_2 = 16, the density of the gas would be 19·45. An allowance for residual nitrogen, still visible in the gas before admixture of oxygen, raises this number to 19·7, which may be taken as the density of pure argon resulting from this determination.

X. DENSITY OF ARGON PREPARED BY MEANS OF MAGNESIUM.

The density of the original sample of argon prepared has already been mentioned. It was 19·09, and after sparking with oxygen, it was calculated to be 20·0. The most reliable results of a number of determinations to give it is 19·90. The difficulty in accurately determining the density is to make sure that all nitrogen has been removed. The sample of density 19·90 showed no spectrum of nitrogen when examined in a vacuum tube. It is right, however, to remark that the highest density registered was 20·38. But there is some reason here to distrust the weighing of the vacuous globe.

XI. SPECTRUM OF ARGON.

The spectrum of argon, seen in a vacuum tube of about 3 mm. pressure, consists of a great number of lines, distributed over almost the whole visible field. Two lines are specially characteristic; they are less refrangible than the red lines of hydrogen or lithium, and serve well to identify the gas, when examined in this way. Mr. Crookes, who will give a full account of the spectrum in a separate communication, has kindly furnished us with the accurate wave lengths of these lines, as well as some others next to be described; they are respectively 696·56 and 705·64, 10^{-6} mm.

Besides these red lines, a bright yellow line, more refrangible than the sodium line, occurs at 603·84. A group of five bright green lines occurs next, besides a number of less intensity. Of the group of five, the second, which is perhaps the most brilliant, has the wave length 561·00. There is next a blue or blue violet line of wave length 470·2; and last, in the less easy visible part of the spectrum, there are five strong violet lines of which the fourth, which is the most brilliant, has the wave length of 420·0.

Unfortunately, the red lines, which are not to be mistaken for those of any other substance, are not easily seen when a jar discharge is passed through argon at atmosperic pressure. The spectrum seen under these conditions has been examined by Professor Schuster. The most characteristic lines are perhaps those in the neighborhood of F, and are very easily seen if there be not too much nitrogen, in spite of the presence of some oxygen and water vapor. The approximate wave lengths are :

487·91	Strong.
[486·07]	F.
484·71	Not quite so strong.
480·52	Strong.
476·50	Fairly strong characteristic triplet.
473·53	
472·56	

It is necessary to anticipate Mr. Crookes's communication, and to state that when the current is passed from the induction coil in one direction, that end of the capillary tube next the positive pole appears of a redder, and that next the negative pole of a bluer hue. There are, in effect, two spectra, which Mr. Crookes has succeeded in separating to a considerable extent. Mr. E. C. Baly, who has noticed a similar phenomenon,* attributes it to the presence of two gases The conclusion would follow that what we have termed "argon" is in reality a mixture of two gases which have as yet not been separated. This conclusion, if true, is of great importance, and experiments are now in progress to test it by the use of other physical methods. The full bearing of this possibility will appear later.

The presence of a small quantity of nitrogen interferes greatly with the argon spectrum. But we have found that in a tube with platinum electrodes, after the discharge has been passed for four hours, the spectrum of nitrogen disappears, and the argon spectrum manifests itself in full purity. A specially constructed tube with magnesium electrodes, which we hoped would yield good results, removed all traces of nitrogen, it is true; but hydrogen was evolved from the magnesium, and showed its characteristic lines very strongly. However, these are easily identified. The gas evolved on heating magnesium in vacuo, as proved by a second experiment, consists entirely of hydrogen.

Mr. Crookes has proved the identity of the chief lines of the spectrum of gas separated from air nitrogen by aid of magnesium with that remaining after sparking the air nitrogen with oxygen in presence of caustic soda solution.

Professor Schuster also has found the principal lines identical in the spectra of the two gases, as observed by the jar discharge at atmospheric pressure.

XII. SOLUBILITY OF ARGON IN WATER.

Determinations of the solubility in water of argon, prepared by sparking, gave 3·94 volumes per 100 of water at 12°. The solubility of gas prepared by means of magnesium was found to be 4·05 volumes per 100 at 13·9°. The gas is therefore about 2½ times as soluble as nitrogen, and possesses approximately the same solubility as oxygen.

The fact that argon is more soluble than nitrogen would lead us to expect it in increased proportion in the dissolved gases of rain water. Experiment has confirmed this anticipation. "Nitrogen" prepared from the dissolved gases of water supplied from a rain water cistern was weighed upon two occasions. The weights, corresponding to those recorded in §I, were 2·3221 and 2·3227, showing an excess of 24 milligrammes above the weight of true nitrogen. Since the corresponding excess for "atmosperic nitrogen" is 11 milligrammes, we conclude that the water "nitrogen" is relatively more than twice as rich in argon.

On the other hand, gas evolved from the hot spring at Bath, and collected for us by Dr. A. Richardson, gave a residue after removal of oxygen and carbonic acid, whose weight was only about midway between that of true and atmospheric nitrogen.

XIII. BEHAVIOR AT LOW TEMPERATURES.†

Preliminary experiment, carried out to liquefy argon at a pressure of about 100 atmospheres, and at a temperature of −90°, failed. No appearance of liquefaction could be observed.

Professor Charles Olszewski, of Cracow, the well known authority on the constants of liquefied gases at low temperature, kindly offered to make experiments on the liquefaction of argon. His results are embodied in a separate communication, but it is allowable to state here that the gas has a lower critical temperature (−121°) and a lower boiling point (−187°) than oxygen, and that he has succeeded in solidifying argon to white crystals, melting at −189·6°. The density of the liquid is approximately 1·5, that of oxygen being 1·124, and of nitrogen 0·885. The sample of gas he experimented with was exceptionally pure, and had been prepared by help of magnesium. It showed no trace of nitrogen when examined in a vacuum tube.

XIV. RATIO OF SPECIFIC HEATS.

In order to decide regarding the elementary or compound nature of argon, experiments were made on the velocity of sounds in it. It will be remembered that, from the velocity of sound in a gas, the ratio of specific heat at constant pressure to that of a constant volume can be deduced by means of the equation

$$n\lambda = v = \sqrt{\left\{\frac{e}{d}\,(1+at)\frac{C_p}{C_v}\right\}}$$

when n is the frequency, λ the wave length of sound, v its velocity, e the isothermal elasticity, d the density, $(1 + at)$ the temperature correction, C_p the specific heat at constant pressure, and C_v that at constant volume. In comparing two gases at the same temperature, each of which obeys Boyle's law with sufficient approximation, and in using the same sound, many of these terms disappear, and the ratio of specific heats of one gas may be deduced from that of the other, if known, by means of the proportion

$$\lambda^2 d : \lambda'^2 d' :: 1{\cdot}41 : x,$$

where, for example, λ and d refer to air, of which the ratio is 1·41, according to observations by Rontgen, Wullner, Kayser, and Jamin and Richard.

Two completely different series of observations, one in a tube of about 2 mm. diameter, and one in one of 8 mm., made with entirely different samples of gas, gave, the first, 1·65 as the ratio, and the second, 1·61.

Experiments made with the first tube, to test the accuracy of its working, gave for carbon dioxide the ratio of 1·276, instead of 1·288, the mean of all previous determinations; and the half wave length of sound in hydrogen was found to be 73·6, instead of 74·5, the mean of those previously found. The ratio of the specific heats of hydrogen found was 1·39, instead of 1·402.

There can be no doubt, therefore, that argon gives practically the same ratio of specific heats, viz., 1·66, proper to a gas in which all the energy is translational. The only other gas which has been found to behave similarly is mercury gas, at a high temperature.

XV. ATTEMPTS TO INDUCE CHEMICAL COMBINATION.

Many attempts to induce argon to combine will be described in full in the complete paper. Suffice it to say here, that all such attempts have as yet proved abortive. Argon does not combine with oxygen in presence of alkali under the influence of the electric discharge, nor with hydrogen in presence of acid or alkali also when sparked; nor with chlorine, dry or moist, when sparked; nor with phosphorus at a bright red heat, nor with sulphur at a bright redness. Tellurium may be distilled in a current of the gas; so may sodium and potassium, their metallic luster remaining unchanged. It is unabsorbed by passing it over fused red hot caustic soda, or soda lime heated to bright redness; it passes unaffected over fused and bright red hot potassium nitrate; and red hot sodium peroxide does not combine with it. Persulphides of sodium and calcium are also without action at a red heat. Platinum black does not absorb it, nor does platinum sponge, and wet oxidizing and chlorinating agents, such as nitro-hydrochloric acid, bromine water, bromine and alkali, and hydrochloric acid and potassium permanganate, are entirely without action. Experiments with fluorine are in contemplation, but the difficulty is great; and an attempt will be made to produce a carbon arc in the gas. Mixtures of sodium and silica and of sodium and boracic anhydride are also without action; hence it appears to resist attack by nascent silicon and by nascent boron.

(To be continued.)

* Proc. Phys. Soc., 1893, p. 147. He says: "When an electric current is passed through a mixture of two gases, one is separated from the other and appears in the negative glow."

† The arrangements for the experiments upon this branch of the subject were left entirely in Professor Ramsay's hands.

‡ Kundt and Warburg, Pogg. Ann. cxxxv. pp. 337 and 527.

[Continued from SUPPLEMENT, 1000, page 15987.]

EXPLOSIVES AND THEIR MODERN DEVELOPMENT.*

By Professor VIVIAN B. LEWES.

LECTURE II.

THE old black powder which has played so important a part in the making of history during the last six hundred years, and the modern modifications of it, to which the last lecture was devoted, is, as we have seen, an excessively intimate mechanical mixture of two combustible ingredients and a body containing oxygen, held in such loose combination that a rise in temperature is able to set it free, and render it available for the rapid oxidation of the other constituents of the powder into solid and gaseous products.

In the burning of the substances to which I wish to draw your attention to-night, we find an entirely different set of phenomena, as the compounds, guncotton and nitroglycerine, differ from gunpowder in being chemical compounds, which contain within their own molecules atoms of carbon and hydrogen, which can be oxidized, and oxygen which can be rendered available for this purpose, the action being prevented in the compound by the presence of the element nitrogen, which, loosely holding the oxygen, prevents any rearrangement of the atomic constituents of the molecule until such time as heat or a sudden jar causes a redistribution of the atoms with evolution of gaseous products.

It is manifest that in an explosive chemical compound, there being only one action to convert the solid into gas, the combustion must of necessity be more rapid than in a mechanical mixture, in which there has first to take place a breaking up of saltpeter in order to render available the oxygen, and then a combination of that with the combustibles present to evolve the gaseous products.

It was in 1832 that Braconnot, in France, observed that by acting with nitric acid upon starch he could convert it into an easily combustible body, to which he gave the name of xyloidine, while some six years later Pelouze noticed that when many fabrics or paper were soaked in this highly corrosive acid they underwent but little change in appearance, but had increased in weight by nearly 80 per cent. and that after all the acid had been washed out from the substance, they manifested a most extraordinary increase in the rapidity with which they were able to burn, and there is no doubt that Pelouze in this observation laid the foundation of the discovery of what is now one of our most important explosives.

It was, however, not until seven years later that the rediscovery of this interesting substance by Schonbein, in 1845, attracted much attention, and it was his proposal to use cotton wool which had been soaked in a mixture of the strongest nitric acid with sulphuric acid and then washed and dried, as a substitute for gunpowder that drew general attention to the use of nitrated compounds as explosives. The process which Schonbein employed he kept secret, and in August, 1846, Bottger found how to prepare this substance, and they together submitted their discovery to the German Federation, but did not make it generally public. In 1847, however, several others discovered the method of preparation, and the manufacture of guncotton became general.

At this time the European powers were nearly as anxious as they are now to obtain a powder which

* Four lectures recently delivered before the Society of Arts, London.—From the Journal of the Society.

would evolve little or no smoke in its combustion, and when the discovery was made that cotton wool treated by nitric acid had the power of burning with enormous rapidity and without the formation of solid residue, Schonbein conceived that it could with great advantage be utilized as a smokeless explosive, but neither he nor any of the chemists of that period were able to make it answer their expectations in this direction, and although nearly every European power commenced experimentalizing with it, it took thirty-five years to bring it within the range of practical utility.

Experiments were at once instituted on a large scale and its manufacture carried on in England and also on the Continent, but in 1847 a very serious explosion occurred at the works in which it was manufactured by Messrs. Hall, at Faversham, while a year later an even more serious explosion took place in the guncotton factory at Bouchet, near Paris; and, as no reason could be assigned for these and other similar explosions, guncotton was looked upon as too dangerous an explosive for ordinary use and its manufacture was discontinued; a result which was further borne out by the decisions of committees, which reported against guncotton as an explosive for use in guns. In Austria, however, General Von Lenk continued to experiment upon the causes which had led to the previous disasters and failures, and he succeeded in showing that if the guncotton were entirely freed from every trace of the acids used in its manufacture, it could be stored and kept with perfect safety, and it is also to the same officer that we owe many experimental facts connected with this substance.

The apparent success of the experiments in Austria attracted attention once more to the subject, and in 1862 the British Association appointed a committee to ascertain all that was known, and to inquire into the possibility of applying guncotton to warlike purposes. Much valuable information was obtained by this committee, with which Sir Frederick Abel was associated, and it was he who first introduced the improved processes of manufacture at present employed in the government factory.

Cotton is one of the purest forms of cellulose, or woody fiber, $C_6H_{10}O_5$, which is one of a class of organic compounds called "alcohols" in which one of the atoms of hydrogen in water has been replaced by some group consisting of carbon and hydrogen, or carbon, hydrogen, and oxygen.

When potassic hydrate is acted upon by nitric acid, the group of atoms HO in the hydrate is replaced by the group NO_2 contained in the nitric acid, with formation of potassic nitrate and water.

$$\underset{\text{Potassic Hydrate.}}{K(HO)} + \underset{\text{Nitric Acid.}}{H(NO_3)} = \underset{\text{Potassic Nitrate.}}{K(NO)_3} + \underset{\text{Water.}}{H(HO).}$$

And in the same way when a small portion of cotton is acted upon by the strongest nitric acid, the group HO in the cellulose is replaced by the NO_2 group from the nitric acid with the simultaneous formation of water.

$$\underset{\text{Cellulose}}{C_6H_7O_2(HO)_3} + \underset{\text{Nitric Acid.}}{3(HNO_3)} = \underset{\text{Guncotton.}}{C_6H_7O_2(NO_2)_3} + \underset{\text{Water.}}{3(H_2O)}$$

If guncotton were made on the large scale in this manner, the water formed during the action would dilute the nitric acid, and would give rise to an inferior kind of guncotton called collodion cotton, in which only two-thirds of the HO groups contained in the cellulose would be replaced by NO_2.

$$\underset{\text{Cellulose.}}{C_6H_7O_2\ (HO)_3} + \underset{\text{Nitric Acid.}}{{}_2(HNO_3)}$$
$$= \underset{\text{Collodion Cotton.}}{C_6H_7O_2\ (HO)\ (NO_2)_2} + \underset{\text{Water.}}{{}_2(H_2O)}$$

And in order to prevent this dilution taking place, the strongest nitric acid is mixed with 2½ times its own volume of strong sulphuric acid, which having a strong affinity for water, absorbs it as fast as it is formed, and so maintains the nitric acid at its original strength.

Accepting the formula $C_6H_7O_2(NO_2)_3$ as representing guncotton, it is seen that the group NO_2 is the oxidizing portion of the molecule, just as in gunpowder the NO_2 contained in the potassic nitrate KNO_3 supplied the oxygen necessary for the combustion of the charcoal and sulphur.

In the manufacture of guncotton, the best white cotton waste only is used, and is supplied free from all grease and dirt, which has been previously extracted by boiling it with dilute alkaline solutions; this is important, as if any greasy or resinous substances remained in the cotton, they would form compounds with the acids employed, which would be liable to cause decomposition.

The cotton is first picked over by hand, all foreign substances being removed, and it is then passed through the "teasing machine," in which rollers bearing iron teeth rotate and tear up any knots or lumps which exist in the waste; after this it is passed through the "cutting machine," which chops it into pieces not exceeding two inches in lengh. If any moisture were present in the waste, it would cause evolution of heat on dipping it in the acids; the cotton is therefore dried by passing it through a chamber heated to about 83 degrees C., in which the cotton placed on endless bands travels backward and forward for about 20 minutes; it is then weighed up into lots of 1¼ lb., called a charge, and is placed in an air-tight box, to keep it dry until it has cooled down and is ready for dipping.

The mixture of acids consists of one part by weight of nitric acid of specific gravity 1·52 to three parts by weight or 2·45 by volume of sulphuric acid of specific gravity 1·84. These are run in the right proportions into a mixing tank fitted with a lid, through an opening in which they can be thoroughly mixed by means of a stirrer, worked backward and forward for some minutes. Mixing the acids is attended by evolution of a considerable amount of heat, and the mixture is allowed to stand until thoroughly cool, when it is run into a dipping pan, a small cast iron tank, holding about 220 lb. of the mixed acids, and surrounded on the outside by running water, in order to guard against rise of temperature during the formation of guncotton, which would tend to increase the percentage of collodion cotton present in the finished product.

The charge of 1¼ lb. of dry cotton is now taken from its tin, and is stirred as quickly as possible into the mixed acids, in which it is allowed to remain five or six minutes; it is then lifted on to a perforated shelf at one end of the dipping pan, and the large excess of acids squeezed out by a plate worked by a lever. The 1¼ lb. of cotton which has absorbed 14 lb. of acids is now transferred to an earthenware pot fitted with a cover, the pot being placed in running water to prevent any rise in temperature, and the charge remains under these conditions for upward of twenty-four hours, when the excess of acids present completes the conversion of the cotton. The next step is to get rid of the free acids which are still present in quantity. To do this the contents of six pots are transferred to a centrifugal machine, consisting of a perforated iron cylinder made to rotate at a rate of 1,200 revolutions per minute, about 10 lb. of acids being in this way separated from each charge of cotton.

The converted cotton is now placed in a cistern of water, where it is kept continually stirred in running water until it no longer tastes acid to the tongue. The guncotton is now again wrung out in a centrifugal machine, and is then boiled for five days in wooden tanks heated by steam coils, the water is wrung out as before, and finally the guncotton should be so far free from acid that it does not redden blue litmus. The guncotton is now reduced to pulp in a machine of the same construction as a paper maker's "hollander," in which the fiber suspended in water is made to continually pass between a bed plate and a roller, both being armed with knives, and after being pulped for five hours, is reduced to a very fine state of division, and then passed through a pipe into the "poaching machine." This is another large oval tank in which paddle wheels keep the pulp constantly agitated with a large volume of fresh water, which, owing to the fine state of division of the pulp, thoroughly washes every portion of it. After six hours in the poacher, samples of the pulp are tested, and if the requirements of the tests are satisfied, enough lime water, whiting, and caustic soda—sodic hydrate—are mixed within to leave between one and two per cent. of free alkali in the finished guncotton. The pulp is now drawn up by means of a vacuum pump into an iron reservoir, called the "stuff chest," in which revolving arms keep the pulp from settling, and from which measured quantities can be run off into moulds, the bottoms being made of a very fine wire gauze, that allows the water to pass through but keeps back the fine pulp, the filtration being aided by the action of a partial vacuum maintained below the moulds.

When most of the water has been in this way separated, hydraulic pressure of about 34 lb. on the square inch is brought to bear upon the semi-solid pulp, which expels a great proportion of the remaining water, and renders the blocks sufficiently hard to bear careful handling. The moulded guncotton is now taken to the "press house," where it is subjected to hydraulic pressure of about five tons on the square inch, which reduces it to one-third of its original bulk, making it so hard that it does not perceptibly yield to the pressure of the finger, and when dry will just sink in water.

During the process of manufacturing guncotton, every precaution is taken to prevent any great rise of temperature during the period when the cotton is in contact with free acid, in order to avoid decomposition of the guncotton with evolution of large quantities of red fumes—oxides of nitrogen—and the formation of oxalic acid and other products, while even a small rise in temperature increases the proportion of collodion cotton present, and so detracts from the value of the finished product. In the second stage of the manufacture—from the removal of the superfluous acid in the centrifugal wringing machine to the moulding of the blocks—the object of all the operations is to thoroughly free the converted fiber from every trace of free acid, and it has been conclusively proved that it was to a great extent owing to the retention of free acid that the explosions which attended the early manufacture of guncotton were due.

Cotton when examined under the microscope is seen to consist of minute tubes, which during immersion in the mixed acids become filled with them, and the last traces cannot be removed by any ordinary rinsing process such as was at first considered sufficient, and when such impure guncotton is packed in cases chemical action is maintained by the traces of acid present, the heat generated being confined to the center of the mass by the non-conducting properties of the cotton surrounding it; the action increases very rapidly with the rise of temperature, and a point is soon reached at which the guncotton becomes ignited. The liability to spontaneous decomposition is much increased when cotton which has not been thoroughly cleaned, or which contains any fatty or resinous matter, is used, and also by the presence of a large proportion of collodion cotton, which is not so stable as the completely nitrated product.

This latter cause undoubtedly was a source of danger in the guncotton first manufactured. This was not left long enough in contact with the acids, so that the complete conversion of the whole of the cotton had not taken place and some less stable products were present. The finished guncotton is tested and the amount of alkalinity determined; the alkaline matter present should not be less than 0·5 per cent. or more than 2·0 per cent.

Having tested the finished guncotton for alkaline matter, it is dried at a low temperature and tested for evolution of acid. This is done by taking a small portion of the finely divided substance and placing it in a test tube with a piece of test paper, moistened with a mixture of potassic iodide and starch, and then gently heating the tube in a water bath at a temperature of 66 degrees C. No discoloration of the paper must take place for at least ten minutes. If there is any free acid present nitrous fumes will be evolved which will attack the potassic iodide, liberating iodine, which at once gives an indication by forming the blue iodide of starch.

The percentage of collodion cotton present is next determined by treating a carefully weighed sample of the guncotton for some hours with a mixture of alcohol and ether, which dissolves the collodion cotton but not the fully nitrated product. When fifty grains of the guncotton are treated in this way for three hours, with frequent shaking, with four ounces of a mixture of two parts by volume of ether and one volume of alcohol, the loss of weight, due to collodion cotton dissolved out from it, should be very small. Unconverted cotton can be detected by treating the guncotton with acetic ether, which dissolves the converted but not the unconverted cotton fiber.

Guncotton differs very widely from gunpowder in its properties, requiring a much lower temperature for its ignition, as gunpowder has to be heated to a temperature of at least 250 degrees C., while guncotton will often take fire at 136 degrees C., and invariably does so below 204 degrees C. Guncotton can be fired by striking it with a steel hammer on an anvil. The explosion, however, is confined to the portion struck, but it is very difficult to ignite powder in this way. The rate at which guncotton burns is dependent upon the mode of its ignition and the conditions under which it is placed. A piece of loose guncotton, placed on the hand, and touched with a hot glass rod, burns away so rapidly that the skin is not scorched or burned. For the same reason, a piece of guncotton can be fired upon a small pile of gunpowder without igniting the powder, and grains of powder can indeed be wrapped up in guncotton and the guncotton ignited without the powder being burnt.

Rapid as this combustion is, however, it occupies an appreciable time, as may be seen by igniting a train of loose guncotton, which takes several seconds to burn a few feet, giving at the same time a large flame. If guncotton be confined at the moment of ignition this flame is forced back into the mass, and by rapidly heating it brings it to the point at which combustion passes into explosion, and prior to 1868, when guncotton was required for destructive purposes, it was always confined in strong cases, but in that year Mr. E. O. Brown, of Woolwich, discovered that when a detonating fuse was exploded in contact with compressed guncotton, the unconfined mass at once exploded with enormous violence, and this discovery of the possibility of detonating guncotton marks the second great stage in the history of the substance.

The fact that certain unstable compounds could be caused to undergo instantaneous decomposition by the sympathetic vibration set up in them by a sharp explosion, either in contact with or close to them, had been previously known, and Nobel had exploded nitroglycerine by detonation some years previously, but another new and most important fact was discovered nearly at the same time, namely, that guncotton, when wet, and containing 15 to 29 per cent. of water, could be detonated, and gave even better results than when dry, provided that a small portion of dry guncotton was placed in contact with the detonating fuse, the explosion of this portion insuring the detonation of the wet mass.

The great importance of this discovery is seen when one considers that the sudden conversion of the solid mass into gaseous constituents endows guncotton when exploded in this way with an enormous destructive power, which is as great when the explosive is free as when it is confined, and that although it can be detonated when wet, in this condition it is not inflammable, and that a hole may be bored through a block of wet guncotton with a red hot iron without inflaming it, a fact which renders it the safest explosive we possess, as it can be stored wet in closed vessels and dried as it is required for use, or even used wet with a small primer of dried guncotton.

The non-explosive properties of wet guncotton, under all ordinary conditions, were demonstrated by the Government Committee of 1871, who constructed two small magazines, and in one placed a securely fastened tank, containing 2,240 lb. of guncotton in disks, while in the second magazine the same amount was packed in eighty closed boxes, 28 lb. in each; in both cases the guncotton contained about 30 parts of water to 100 of dry material. The remaining space in the magazines was now filled with shavings and other inflammable material, which were fired. In two hours the entire contents had burnt away, but without the slightest sign of explosion, although the heat generated was very great, as was shown by the distortion of iron bars upon which the cases had rested.

If dry compressed guncotton is ignited by touching it with a hot rod, it burns away with a fierce flame, but without explosion, but if larger quantities were ignited in this way, the portions first burning would quickly heat up other parts of the mass to the temperature at which combustion becomes explosively rapid, and as soon as this point was reached detonation of the whole mass would take place.

The great increase in effect gained by detonating such explosives as guncotton arises from the enormous increase in rapidity of explosion. A train of ordinary guncotton fired by a hot rod takes several seconds to burn a distance of a few feet, but if a train of compressed guncotton was fired by detonation, the explosion would travel at the rate of 200 miles a minute. When guncotton is fired by touching it with a red hot rod, its combustion occupies an appreciable time, and the gaseous products evolved have time to find space for themselves in the surrounding air. If, however, detonation be employed, the conversion of the solid into an enormously increased volume of gas takes place instantaneously, and the atmospheric pressure forms just as good a "tamping" for the guncotton as the strong metal cases which were employed before the principle of detonation was recognized.

In order to detonate guncotton, fuses charged with mercuric fulminate are now generally employed.

Several theories have been brought forward to explain the phenomena of detonation, the first being that the vibrations caused by the detonator are able to set up similar vibrations in the body detonated, and that these vibrations start a sympathetic decomposition, and determine its instantaneous resolution into the products of explosion.

When a particular note is sounded on a violin, the string of a second similar instrument will spontaneously vibrate and emit the same note, and the same synchronism of vibrations in the detonator and explosive are—according to Sir Frederick Abel's theory of detonation—the cause of the explosion.

The facts which most strongly support this view are that the detonators which will cause explosion of one compound must be varied to fit them for producing a similar result with a different explosive, and also that the detonation of a small disk of guncotton at one end of a tube three feet long will produce detonation of a similar disk at the other end of the tube, although if the disks are in the open air, they must be placed within half an inch of each other for detonation to take place.

(To be continued.)

RARE ANIMALS IN THE ZOOLOGICAL GARDEN AT BERLIN.

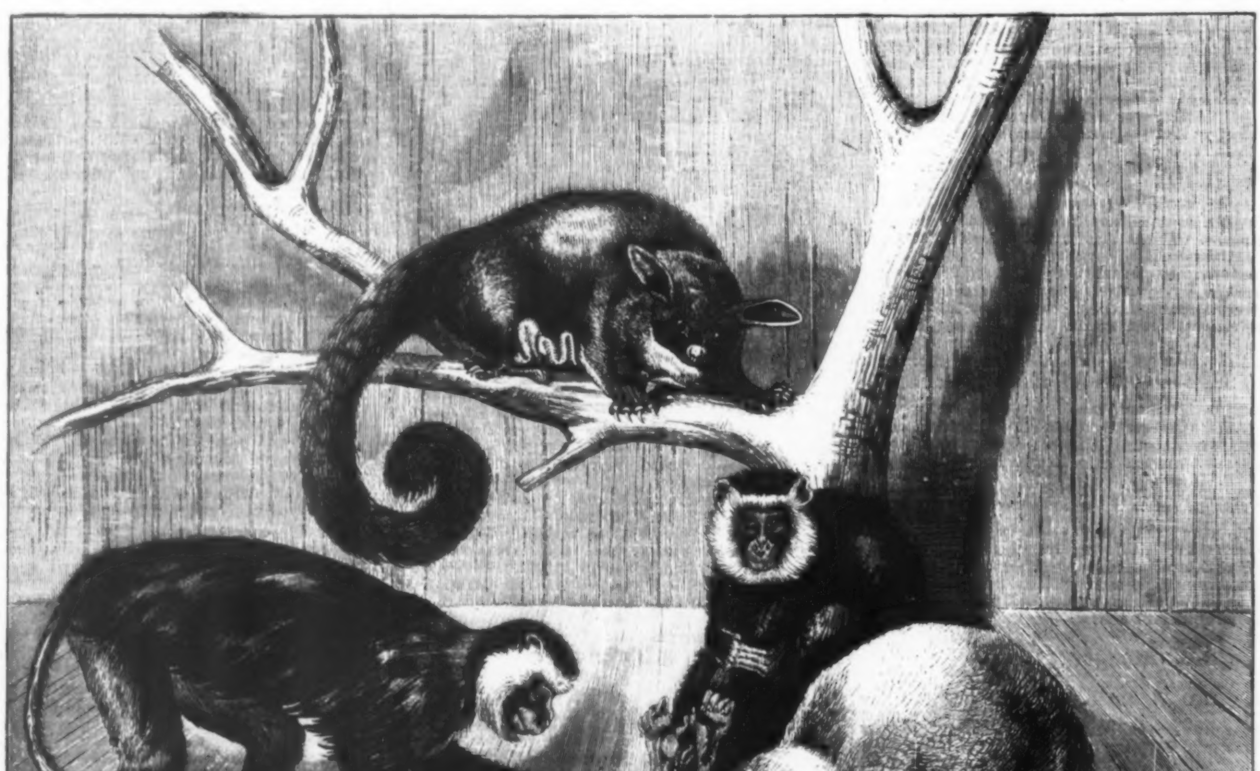
UNDER the capable guidance of the energetic and zealous Dr. Heck, the Berlin Zoological Garden has developed into a model institution, containing a greater variety of living animals than any other in Europe. It is a collection that not only offers an inexhaustible source of information to the naturalist, but also delights the zoologist.

The animals shown in the accompanying drawings are specially interesting, being representatives of three different continents. The monkeys come from the western coast of Africa, the native land of the badger is at the foot of the Himalayas, and the home of the flying phalanger is in the thick forests of New South Wales.

The Colubus vellerosus Js. Geoffr. is a German subject, having come from Togo, on the Gulf of Guinea, where he was found by the traveler Kling, but he had long been known to the inhabitants of the neighboring Gold Coast. The characteristic feature of these monkeys is the rudimentary thumb on the forehand. They are near relatives of the Guereza, of Abyssinia, and belong to that family of monkeys that is distinguished by the absence of the cheek pouches and by a divided stomach, almost like that of the ruminants, the typical representative of this family being the sacred monkey of the Hindoos. They live in small companies in the hilly land along the rivers of the coast region, where they are most at home among the tops of the highest trees, and their chief nourishment consists of the young shoots and tender leaves. The monkey which we show is one of the most beautiful quadrumana of the Dark Continent; the snow-white hair around its face stands out in relief against the long, silky black hair on its back; the outsides of the thighs are gray, and its very long tail is white. When young, its whole coat is white. Eight different types of these black and white monkeys with the rudimentary thumb are known, which live in that part of Africa between Southern Abyssinia and the Congo, one particular type being found in each district. It is very probable that this ape will some time be prized for its beautiful fur, and, in fact, monkey fur has already been used for ladies' muffs and coachmen's capes.

In the foreground of the engraving we have the Indian badger, Arctonyx collaris F. Cuv., whose most noticeable peculiarity is the shape of his snout, which is so like that of the hog that it has gained for him the name "hog-badger." His face is marked with two dark bands, and there is a white spot on his neck. He is a lazy, sleepy creature, and if disturbed he rages around in his cage with his nose in the air, sniffing like a hog. In his native land, the rocky regions of the Eastern Himalayas, from Nepal to Pegu and Tenasserim, he leads a nocturnal life, not leaving his hole until late in the evening, when he goes in search of prey. He is no epicure, but relishes anything that he can find; earth worms, roots, lizards, are as acceptable to him as mice, and, when he can get them, crabs and fish, which he is very skillful in catching. His gait is something like that of a bear, and, like the latter, he sometimes stands on his hind legs.

The yellow-bellied flying phalanger, Petaurus australis Shaw, is also a nocturnal beast. He sleeps during the day, with his tail rolled up, in the forks of branches, or in hollow trees, but at night he prowls in the highest branches, sometimes seeking the honey in the immense blossom of the rubber tree, sometimes hunting for insects. On the ground he can only move slowly and awkwardly, but in the tree tops his movement is much more elegant, and the fold of skin that extends along his flanks enables him to take long leaps from tree to tree, his tail serving as a rudder. This pretty inhabitant of Australia has thick, woolly fur, and his bare nose and long ears give a peculiar expression to his face. He takes about the same place among the marsupialia that the flying squirrel does among the rodents.—Illustrirte Zeitung.



RARE ANIMALS IN THE ZOOLOGICAL GARDEN AT BERLIN.—Drawn from life by Anna Held.

THE POLECAT.

By T. A. W. Rees, F.R.M.S.

THE polecat has, as its nearest of kin in the British Islands, the stoat and weasel. It is scientifically known as Mustela putorius. It has a slender, supple body, short muzzle and legs, thin wiry tail, small round ears lying flat on the skull, and sharp, cruel teeth. While exceeding both stoat and weasel in size, it is comparatively thicker, too, in build and general appearance. The creature is enveloped in soft, close coat of very fine fur, dirty yellow in color, but a coarser covering of hair, black or dark brown, stands out sparsely over this garment. On the back and tail this coarse hair is long, but short on legs, face and throat.

During the polecat's visits to rabbit warrens, all dew or damp loam is collected on this long hair, and does not reach the closer fur beneath, which under-garment is consequently protected from becoming matted and the skin from growing diseased. The snout is tipped with white. On the approach of old age, the polecat assumes a venerable gown of gray.

Parasites are generally found in plenty on the polecat, and in confinement the animal is usually attacked by mange. When enraged it has the power of erecting the hair along the spine and tail just in the same way as that in which an infuriated cat shows displeasure. Its food is, to speak tersely, flesh, blood and water. Ravenous habits, the outcome of insatiable desires, are the chief characteristic of this untiring murderer, which—like a wasp that, deprived of its abdomen, still clutches its prey—would almost glory in its bloodthirstiness while sweating in the throes of death.

Where rabbits are numerous, the polecat exists chiefly upon the brains of these rodents, though an occasional rat, field-mouse, mole, or bird is not despised as a change of diet. It hunts its prey by scent, following the trail as surely as the steadiest beagle, moving with a quick, sinuous motion, alternating in a series of short leaps. When pressed, a rabbit takes refuge in its warren, to be mercilessly ejected thence by its enemy and chased from burrow to burrow, until, hidden in the farthest corner of its lair, or among the tangled undergrowth, the poor, frightened thing is fain to give up the struggle for life, and unresistingly await, with fluttering heart, an awful death. The fittest survives, the weakling goes to the wall—such is nature's inexorable law.

Sometimes, however, there is a happy exception to the rule. Perchance a violent kick from the rabbit's hind feet may lay bare the entrails of its foe; or, if the burrow is tenanted by many occupants, the polecat may be baffled by the strong taint which lies on the much-frequented paths to and from the neighboring covert. Should a particular warren be frequently visited, its inhabitants will invariably migrate in a body to other quarters, until in turn driven out from these retreats, they go back to their former abode after the vile odor, which a polecat always leaves behind it, shall have passed away. The breath of putorius is strong and offensive; its skin emits a powerful scent, and—worse than all this—a gland near the tail is full of a rank fluid, which the creature discharges at will, but only when much enraged. Terriers have been known to give up their attack directly upon the arrival of this effective aroma upon the scene. I once treated a polecat that had been trapped alive for me by holding it down with a fire tongs at the bottom of a deep cask, while I stunned and afterward killed it with a poker. Although I can put up with many a trifle, I very much question whether I could have held my nasal organ over the cask for more than the time which was occupied in belaboring that polecat to death.

The polecat chooses for its home an old drain or rabbit burrow. It will even utilize the abode of an evicted stoat, enlarging it as necessity prompts. The locality of its haunt will generally depend upon the size of the occupants, for the polecat, though generally measuring about sixteen inches from nose to root of tail, sometimes attains a length of twenty inches. Five is the average number of the litter of young. While suckling these in the warm nest of leaves or hay at the bottom of her burrow, the polecat is even more than usually ferocious; and it is at this season that the female is most generally seen, while hunting some fat coney from over the way among the evening shadows. Were it not for the hunger of maternity, night would come before the cautious mother ventured forth.

In days now past, we who were schoolboy naturalists pursued our studies of Nature's face among the dingles and woods of what was known as the Tunnel, from a deep gulley, overhung with precipitous rocks some two hundred feet high. While one day in early spring we of the brotherhood were walking along at the foot of these crags, to visit a pond in quest of objects for our microscope, some loose earth and stones came crashing from the summit. Judge of our astonishment when we saw that a struggle was going on among the rolling debris. We rushed to the spot, sticks in hand, to find that a large polecat was holding on to a kicking, squealing rabbit. The former was at once dispatched, a female with teats large and flesh-colored. The rabbit, incapable of thinking about anything but squealing and kicking, was perfectly hysterical with fright, so one of us stowed away the frightened bundle of fur under his coat and carried it home to be comforted, fed and set once more at liberty. We found that the polecat had seized her prey

by the eyelid. This is generally the point of attack, and one can well imagine the agony of the victim while a cruel monster is endeavoring to get at its brain, first of all tearing away the eyeball and devouring it. Sometimes the brain is reached from immediately between the ears, more rarely through the orifice of the ear itself.

Such, then, is a brief history of this representative of the weasel family, which, according to rustic belief, fascinates its victim with its piercing gaze, thus bringing on a hypnotic trance, during which the medium is incapable of self-defense.—Science-Gossip.

NEW CARNATIONS.

THERE are now so many raisers of carnations that it becomes a matter of careful study to judge the value of the new varieties placed before the public at the various exhibitions. What the public really do want in carnations is not new varieties, merely differing little from those already in existence, but some improvements in form of flower, or habit of the plant; and these improvements must be accompanied by decided color in the flowers, in order that the plants may be effective in the mass in the flower garden.

Another class of cultivators we have among us—the old florists—a class of men to whom but scant courtesy is meted out by some horticultural writers. But the florist does not trouble himself over-much about what the press says of him; he pursues the even tenor of his way, working up toward a high standard of excellence difficult to attain; but the pleasurable excitement of the florist's pursuit compensates for the numerous disappointments he meets with.

The florists' favorite flowers are the bizarres and flakes in carnations, and the different classes of edged flowers in picotees. In the effort to obtain good varieties in these classes, some of the best selfs have been produced. King of Scarlets, scarlet self; Rose Celestial, a fine, clear rose self; Ruby, deep rose, were all produced from seed saved from flakes and bizarres.

Very beautiful self-colored varieties—red, rose and purple—have also been obtained from picotees. The variety Purple Emperor came among a batch of seedlings from Her Majesty, a fine wire-edged picotee. One of the most distinct, and in some respects the most remarkable, carnation produced from seed in recent years is King Arthur, raised in Mr. Martin R. Smith's garden at Hayes, which came as a chance seedling, the parentage unknown. This variety produces flowers of a crimson scarlet color, as large as the Malmaisons; and the calyx never bursts or splits, a very serious fault in carnations with large flowers.

CARNATION, MRS. ERIC HAMBRO.

The new varieties exhibited during 1894, and were awarded certificates or awards of merit, were: Horace Trelawny (Martin Smith), a fine rose self, the flowers of the largest size and of good form; Eudoxia (Douglas), exhibited from Mr. Martin Smith's garden in splendid form by his gardener, Mr. Charles Blick, as a pot plant—the flowers large, well formed and of rather a paler tint than Horace Trelawny; Braw Lass (Martin Smith), salmon-pink self, is of good habit, and has flowers of excellent form; Fiery Cross (Martin Smith), is a scarlet self, a class containing many fine varieties and including Hayes Scarlet, and it is sufficient recommendation to say that this is a distinct acquisition; Sir John Falstaff (Martin Smith) is a crimson-scarlet; a very fine white variety is Mrs. Eric Hambro (Martin Smith), and, as will be seen by the accompanying illustration, it produces the largest and best formed flowers of any white variety yet raised.

The mistake a good many amateurs make with their carnations is to put the carnations in borders already exhausted by other plants. No preparations are made for the roots, and the result is a puny growth and flowers of poor quality. The carnation desires a rich, deep soil and careful handling.

THE WATER LILY PEST.

IF the Russian thistle question comes up in the next Congress on an application for an appropriation to destroy it, it is likely to have a companion in the so-called "water lily," which is overrunning Louisiana, and which, if it continues to grow as it has been spreading of late years, will soon prove a very serious nuisance. The United States spend a large sum annually to keep the Mississippi and its tributaries clear of snags and stumps, having a regular snagboat service for this purpose. When it undertakes the removal of the water lilies, which it probably will be compelled to do sooner or later, it will find the removal of snags and stumps a trifle in comparison.

The water lily, or more properly, the water hyacinth, is of recent origin in Louisiana. It is said that a man from New Orleans visiting Colombia three years ago was attracted by a very pretty aquatic plant he found growing in a tub at the residence of a rich planter. He brought some bulbs of the plant home and grew them in his front yard. Nothing was heard of the water hyacinth for some months afterward. It is not known how it spread, but about two years ago patches of a green seaweed, with a very beautiful pale blue or purple flower, were found floating in Bayou St. John, which connects New Orleans with Lake Pontchartrain. The patches grew rapidly larger and got so thick and dense as to look like floating islands. The roots matted together, and the dark olive green leaves so concealed the water from view that one might easily have been tempted to walk on it as solid ground. Within one summer the lilies had grown so dense as to interfere with the navigation of the bayou, and large quantities of them were dragged out and piled on the bank.

The lily question soon became an important popular issue in New Orleans. The people living along Bayou St. John and in its neighborhood protested that the lilies caused an odor which was most offensive to them, and that when the wind blew from the direction of the bayou it became almost insupportable. The board of health appointed a commission to examine the matter. The commission found that the plants were not lilies, and that they did not cause the odor. It declared the lilies innocuous to the public health, although a serious hindrance to navigation, and declared their removal unnecessary. This was a year ago. Since then the lilies have attracted less attention, but they have become steadily worse, and are seriously impeding navigation. Just at present they are probably not so conspicuous as they were last fall, for the freeze has caused their leaves to fall off, but the roots and bulbs are there, and when the spring comes around Louisiana will be able to see how the lilies have gained on it. They have overrun the entire country around New Orleans. Its fifty miles of canals are so overgrown with them that not a drop of water can be seen, and the canals look like prairies. The swamps are hidden from view by the dense growth of the lilies. The new canal and Bayou St. John are nearly dammed up with them. In Lake Pontchartrain immense masses of lilies are floating, wafted hither and thither by the wind and tide, and foretelling the day when the lake will become a Sargasso Sea. The lilies floated thirty-five miles across it last year, and now the steamers going up the beautiful Tchefuncta River have to force their way through a solid field of lilies.

Last year the lilies made their appearance on the other side of the Mississippi and 100 miles west of New Orleans. Here they are doing even more harm than in New Orleans, for they are threatening to strangle the lumbering industry and interfere with other pursuits as well, and to ruin the drainage of the country.

In Terrebonne parish, for instance, the lily has grown so serious a nuisance that the police jury, equivalent to county commissioners in other States, recently met to decide what should be done to check the evil. Terrebonne is cut up by innumerable bayous, upon the banks of which the population mainly lives, and which furnish the chief means of communication of the parish. The lily reached there over a year ago. It has now completely blocked up portions of Bayous Teche, Chene, and L'Ours. Lower Bayou Black is closing up, and the sawmills at Gibson City find it impossible to float logs there any longer. A citizens' committee was organized on Bayou Chene and a considerable sum raised to fight the lilies. Men were employed to cut them out with hooks and drag them to the banks in order to keep the channel open; but it has been found that the lilies grow so rapidly that it is necessary to have the men steadily at work to keep them down. The general conclusion was that those bayous already invaded were lost beyond redemption, and that the best thing the people could do would be to try and save Bayou Black, Lake Cocodrie, and such bodies of water in the parish as still remain uninvaded. It is even proposed to station a man at the mouth of Bayou Black, whose sole duty it shall be to see that no lily floats or is carried into the waters of the Black. Unless this is done, the sawmills doing business on that stream will be compelled to suspend operations.

Terrebonne is a fair sample of all the lower parishes of Louisiana. All the others are threatened in the same way, and as the lily seems to be traveling at the rate of 100 miles a year, it is simply a question of time when other States begin to suffer from this nuisance.

What the habits of the lily are in its Colombian home are not known, but in this climate it seems to have gained new vigor and strength. As about 20 per cent. of the area of Louisiana is water, and nearly all the streams sluggish, with scarcely any current, it seems to be simply a question of time when they will all be closed up by the South American water hyacinth. The plant grows with unexampled rapidity. At two weeks old it is two feet in length. In a month fine wiry roots run from the plant to the bottom of the stream. A thick, mossy substance forms around their roots, which begins growing at the lower portion of the lily when the plant is young and increases in its downward growth as the plant matures, until it forms a mass in the stream that even a fish cannot get through. From this mass stray lilies are broken off by the wind or the current. These float a few miles, throw out their roots, anchor there, and become the nucleus for a new growth. The rich, decayed vegetable matter that is drained from the swamps into the streams of lower Louisiana seems to invigorate the lily, and that and the sluggishness of the Louisiana streams seems to be the reason why the water hyacinth has become so much more vigorous a plant in this country than it is in South America, where it is an innocent pond ornament. In Louisiana it seems to change all its habits. After filling up the stream it becomes a land plant. In Bayou Chene it grows ten and twelve feet above the water's edge, and in portions of the bayou, where it is left unmolested, it looks more like a tree than a water hyacinth.

The lily has been spasmodically attacked two or three times, but little has been done in the way of destroying or even checking it, and the people do not seem to realize the danger ahead; indeed, because the unprecedentedly cold winter has checked its ravages considerably for the present, there is a disposition to regard it not as dangerous as it threatened to be at first. This, however, is probably a delusion, and a great many persons see in it a very serious danger. It is not alone that it will strangle the lumber industry, or even that it will interrupt transportation and communication, but that it threatens to ruin the drainage of southern Louisiana. That section, being so level, requires all these bayous for its proper drainage, and if they are to be shut up it is difficult to say what will be the effect on the country. The South American water hyacinth threatens to materially change the condition of affairs in the swamps and bayou country of Louisiana and other Southern States, to which it must spread in time—indeed, it is already invading Mississippi—unless a way of getting rid of it is found.—New York Sun.

THE RED CEDAR.

THE red cedar, which is not a cedar at all in the botanical meaning of the word, but a juniper, is one of the commonest and most widely distributed trees of North America. Indeed, it is not easy to recall any other coniferous tree which inhabits such an extended area, with the exception of another plant of the same genus, the Juniperus communis, found in various forms in all northern countries, and the great Siberian spruce, Picea obovata, which ranges from the eastern borders of Russia to the Manchurian shores of the Pacific Ocean, and to central China. The red cedar is equally at home on the dry gravelly hills of New Brunswick and New England, on the northern shores of Georgian Bay, in the fertile valleys of Pennsylvania, on the limestone hills of eastern Kentucky and Tennessee, where it forms, with stunted shrubby growth, great forests or "cedar breaks;" in the swamps of the Florida peninsula, and on the rich bottom lands of the Red River and its tributaries, where it grows to its greatest size. Less common in the West than in the East, the red cedar is apparently as much at home in one region as in the other; it is scattered over the eastern slopes of the Rocky Mountains of Colorado; and when the Mission of Santa Fe was established, the Spanish priests might have seen it on the cliffs above the stream that enabled them to change a desert into a garden; it flourishes in northern Arizona, where the melting snows of the Rocky Mountains pour through the mighty chasm that divides the Colorado plateau, and it grows on the borders of lakes and streams in northern Montana and Idaho, and on Vancouver's Island.

The habit of the red cedar is as varied as the regions it inhabits. Sometimes it is bushlike, with many spreading stems, and at others it grows nearly a hundred feet tall, with a beautiful straight trunk four or five feet in diameter; sometimes all the branches are wide-spreading and form a symmetrical round-topped head; at others they are pressed close to the stem and the tree is pyramidal, with a narrow, spire-like top. These varieties of habit do not appear to be governed by any recognized conditions of environment. Often pyramidal trees grow side by side with round-topped or bushy ones, and in old age they all appear to lose their pyramidal habit and to become round-topped. The pyramidal habit, however, is, perhaps, rather more marked and constant in fertile lands, such as are found in the valley of the Hudson River and in eastern Pennsylvania, than it is in New England, although pyramidal trees are common there. Of remarkable constitution and possessed of great powers of adaptability to varied climatic conditions, the red cedar only displays its full size and develops its greatest value in the warm and humid atmosphere of the South, and at the North and in the far West it looks as if it selected some particularly exposed and wind-swept hill for its home in order to show its toughness and indifference to the comforts of life.

The earliest European settlers on the Atlantic seaboard delighted in the red cedar, which reminded them of some inhabitant of their Old World gardens, and in its bright red fragrant wood, which the Indians had known and valued before them; and the narratives of the old voyages and settlements usually describe the cedar which was often included in the lists of treasures yielded by the new-found land. They did not exaggerate its value as they did that of the sassafras and many other products of the American soil. There is no tree in America that will grow better fence posts, for the wood does not decay and insects do not molest

it. A well selected red cedar post will last an incredibly long time in the ground, and for the sills of buildings placed immediately on the soil no wood is more valuable. Moths flee from its pleasant pungent odor, and every good housekeeper knows the value of a red cedar chest, or a closet lined with this wood. Red cedar is the wood of lead pencils; and practically the wood in all these indispensable articles, at least in pencils of good quality, is the wood of this tree from Florida, where there are great factories belonging to German manufacturers, devoted to cutting up cedar wood into pencil stock. Every artist in all the civilized world, every man of letters, every school teacher, all the bankers, lawyers and other men of affairs, the men and women who control the world, and all the school children who are going to control it, hold every day in their hands a piece of this wood. It would be interesting to know what proportion of these men and women, the most intelligent and best educated of the human race, knows anything of the origin of these little cylinders of wood, of the character and appearance and of the name even of the tree that builds them up in its long life of slow accretions.

It is not our purpose to speak now of the botanical peculiarities of the red cedar, the Juniperus Virginiana of botanists, because they are perfectly well known to every one who is interested in trees in their scientific aspects, but of its horticultural or decorative value as an ornamental plant, because it does not seem to be fully appreciated or recognized in American plantations, at least in the Eastern States, although in the West a few years ago it was largely grown by nursery men and planted in considerable numbers on the plains and prairies of the Missouri River basin. In all the Northern States the red cedar can be made to take the place in formal gardens of the cypress, to which the gardens of southern Europe owe so much of their charm, and which cannot be grown in our severer climate. If it is desired to produce certain effects in a garden by the use of trees that are formal in outline, the red cedar will produce this effect better than any other tree that is hardy here; and if trees cut into fantastic shapes such as delight the Chinese or the Japanese, from whom the Dutch learned this fashion, no tree bears with less injury than the red cedar the annual suppression of its growth under the gardener's shears. In natural gardens also the red cedar can be made to play a useful, and sometimes an important, part, as no tree is better suited to enliven a broken, rocky hillside or to crown its top with its dark green foliage, which in autumn is studded with bright blue berries. Other coniferous trees with pyramidal habit, like the arbor-vitæ, are often planted in such situations; but the arbor-vitæ is a gregarious tree and an inhabitant of swamps and low river banks, and when it is made to stand out alone on a hill it never looks at home or in harmony with its surroundings, while the red cedar, of all our trees, most easily fits into its place in the landscape, and, perhaps, no one ever saw a red cedar that looked out of place in connection with its associates in any American sylvan landscape. As a hedge-plant the red cedar has not proved very successful; the plants grow too slowly for the impatient American, who wants his hedge to grow as rapidly as a carpenter could build one with boards, and the branches often die out, making here and there ugly gaps.

Like most other trees, the red cedar is easy to raise from seeds when the person who undertakes to do it understands its peculiarities. The stone inclosed in the fleshy berry of the juniper is very thick and hard and it takes a long time to soften so that the seed can get out and begin to grow. Planted in the ground in the ordinary manner, a juniper seed will sometimes lie for years without germinating, and the way to treat them is to soak the berries thoroughly in warm water as soon as they are ripe in the autumn, mix them with sand, bury the whole mass in the ground in some place where they will keep moist during the following summer, and then plant them either in the autumn, a year from the time they were gathered, or in the following spring. Treated in this way, the seed will germinate in a few weeks after they are planted, and produce strong plants the first year, which will be six or eight inches high at the end of the second season, and ready to transplant. Nurserymen do not raise red cedars very often now, for there is no great demand for them. Young plants can be transplanted from old pastures, however, or from the sides of walls or fences, where the seeds dropped by birds germinate in great quantities, producing the long lines of cedar trees which are conspicuous and beautiful features of the landscape in the Northern and Middle States.

The red cedar is a long lived and hardy tree, and if any man has a fancy to plant for posterity or to preserve his memory in a tree, there are few trees that he can plant with greater assurance of attaining the object of his ambition.—Garden and Forest.

THE IRRIGATION QUESTION IN NEBRASKA.

The successive years of drought in the western part of Nebraska has brought forth a general conviction that its lands will not produce without irrigation.

The rainfall cannot be relied on, as has already been proved, to the great distress and financial ruin of hundreds of people that invested their all in buying and stocking farms.

Now that the question of irrigation has taken a firm hold on the people in the country, another question arises. Where are they to get their water from? This could readily be answered by the people living along the Platte, the Loup and several other smaller streams that furnish water throughout the year. But as to the southwestern part of Nebraska, the question still remains unsolved. It is that part of the State which is drained by the Republican River, a stream that has for two years in succession gone dry for a distance of one hundred miles and left the several rudely constructed irrigation ditches high and dry. But that there remains an untold quantity of water in the underlying sand that composes the bed and bottom lands of the stream is without doubt, and has demonstrated itself in more than one way. As, for instance, it could be seen in the fall of the year, when the excessive evaporation gave way to the cooling atmosphere, that the dry bed of the river began to show moisture, then, as the weather grew still colder, small pools of water made their appearance in the depressions of the river bed; finally, in about six weeks, quite a stream of water could be seen flowing, making the river look again like itself, although not a drop of rain had fallen in the country for months.

The utilization of this underflow is the main point which engrosses the minds of the several local engineers of the southwestern part of the State, but it cannot be brought to any successful issue, as there is no corporation that will lay out any large sums of money for irrigation purposes until it has been decided if Congress will make ways to utilize the sheet water below and help the farmers to put it on the parched land. There are many and some very good plans by reputable engineers that could be adopted in establishing irrigation plants, if only Congress would provide the necessary means. It is already known that water in abundance is there, and all it needs is funds to bring it up. How much wiser would it not be to expend money to get water from where it is known to exist than to expend enormous sums trying to blast rain out of clear skies with dynamite.

As it now is there can be no success, for each individual farmer with his small capital cannot erect any pumping plant outside of the common windmill which they have to rely on the wind to operate, and that also fails when water is most needed.

Reservoirs for storing water would not be successful, for the want of appropriate localities, which the level country does not afford. It is a fact, though, that if the government does not adopt some measures to irrigate the lands the country will become a barren waste, where once the thousands of buffaloes grazed and afterward the hardy frontiersman tilled the land with success for a few years, only to be brought to poverty and distress through the fickle play of the elements.

F. G. W.

[From the New York Sun.]

MAKING AN ORANGE GROVE IN FLORIDA.

Orange growers say that $500 an acre is the lowest sum for which wild land can be converted into a bearing orange grove. This looks formidable to a man with little or no capital, when he considers that he must have at least ten acres of trees to give him eventually a respectable income. But the outlay is spread over eight or ten years, and if the grove maker is an able-bodied man, he can put in his own labor for a large share of it. Besides, only a small part of the expense comes at the beginning. Doubtless this is why so many poor men have gone into orange growing and have done well at it. When a grove is in full bearing it is worth from $500 to $1,000 an acre, according to circumstances, and a grove may be so productive and so well kept as to sell for $2,000 an acre, but that is a fancy price, and the purchaser must be some Northern capitalist.

The real estate agent and the man with a grove to sell have their own accounts to give, and the grower with three or four trees that sometimes produce fifteen boxes of oranges each may try to convince you that that is the average production of all his trees. But it is the successful grower who began with the pine woods and stuck to it until he has a good grove in full bearing whose statements are most to be depended upon. The facts and figures to be given here about the making of an orange grove were obtained from such a man, one who is a recognized authority in this orange country, and who has no land to sell.

The stranger of small means who arrives in the orange country intending to go into the business usually finds that he must go from three to five miles back from the railroad for his land. Everything near the stations has already been bought and planted, and has become more valuable with every year's growth of the trees. But it is hardly possible in the orange belt to find any place that is more than five miles from a railway station, for railroads are as thick in this part of Florida as in New Jersey. A driver with a mule and buckboard takes the stranger out to see a piece of land for sale, and in ten minutes he is in the midst of the pine woods. The road is a mere wagon track through the sand, winding among the trees, skirting the shores of lakes, sometimes running directly through them. He begins to feel as if he had about reached the limits of civilization, when there is a turn in the road, and in front of him is a plantation that delights his eye—a big house with broad verandas, a whole village of outhouses, the yard a bed of flowers, perhaps a fountain playing in the center, and all around a forest of orange trees loaded with fruit. This is one of the peculiarities of buckboard travel in the orange country; just as you begin to think yourself isolated from all mankind the road turns, and a picture of tropical comfort lies before you.

The driver gives his passenger a vast amount of information about land and prices, for every boy here knows all about the orange business by the time he is big enough to drive a mule. He could hardly help knowing, hearing nothing all his life but June blooms, percentage of ammonia, budded trees, and the prospects for next year. The road goes through a big patch covered with palmetto scrub and a few scrawny bushes, and the driver turns up his nose at it.

"How much is such land as this worth?" the stranger asks.

"About one cent an acre," the driver replies, "if somebody else will pay the taxes on it. You couldn't raise oranges on that land, not if you covered it a foot deep with fertilizer. It's no good at all; the more fertilizer you put on the quicker your trees would die out. What you want is good pine land. Wherever you see tall pine trees growing there's good orange land. Blackjack and other hardwood land is only second rate for oranges. Hammock's the best land, of course, but it costs too much to clear. If you stick to good pine land, you'll come out all right." The driver has no land to sell, and his opinions are impartial, and mainly correct.

The stranger notices that besides the big lakes, which sometimes are miles long and broad, there are a great many small ones, pools hardly large enough to be called lakes, covering an acre or two. The road goes through some of these, around others.

"Why is it that you drive right through some of these little ponds," he asks, "but drive around others? Why not go through all?"

"I don't want to drown us both and the mule, too, sir," the driver laughs. "The ponds I drive through are only low places where the rain collects, not more than six inches or a foot deep. The ones I drive around are sink holes full of water, anywhere from forty to seventy-five feet deep, or sometimes with no bottom found in them at all. How do I know them apart? Well, I follow the wagon track. When you drive into one and the mule begins to swim and the wagon sinks, then you know it's a hole."

When the land is reached it is fair pine woods, with little underbrush, because the underbrush is burned out nearly every year. The stranger sees at the first glance that there is work before him if he buys that woodland and turns it into an orange grove. It is beautiful to look at, a groove of tall pines without a branch below the tops, the ground carpeted with pine needles, the air fragrant with the scent of pine and midwinter flowers. It is just as nature made it, barring a wagon track or two running through it. The soil is pure sand, and nothing is in sight but straight trees, and perhaps a lake and a hammock. The original word hummock disappeared from Florida years ago, and every piece of low, moist land covered with dense vegetation is a hammock. The soil in the hammock is black and rich, good for oranges and better yet for vegetables. Underlying the black stuff, may be ten feet down, may be only a foot, is the same old sand. The black muck is the decayed leaves and branches of centuries, that when cleared will retain its richness for some years; after fifteen or twenty years of cultivation it will grow lighter, and eventually it will be light sand again, as it was ages ago.

How much is this pine land worth? is the inevitable question. Twenty-five dollars an acre, says the owner. Five dollars an acre, says the disinterested driver. Either may be right, much depending upon the situation. If there is a fine lake adjoining, with the land sloping gently down to the shore, and another slope on the other side ending in a similar lake, making a sight that is worth something for its beauty as well as for its productiveness, it may possibly be worth $25 an acre. But that is a high price for wild pine land in a rural situation, remote from a railway station. There is some bargaining over the price, as there is anywhere; and it ends in the stranger buying the land at from $5 to $10 an acre. If he gets it for $5, it is not too cheap; if he pays $10, it is not too dear. For a ten acre grove he is not likely to buy merely the ten acres. He must have room for his house and outbuildings, space for a garden, grazing for his cattle, and some woodland for timber and fuel. He is more likely to buy fifty acres than ten, and this is wise.

Here is the stranger, then, with fifty acres of pine forest, ten acres of which he intends to convert into an orange grove. His first work is to clear the ten acres he is to plant. If he is a lazy man, he will merely "ring" the trees, cut a ring around each one with his ax, and leave it to die, decay, and fall down. This is the first sign of a slouch. Long before the trees fall the young orange trees are set out, and in falling the pines are sure to crush and destroy a number of them. The ship-shape way is to cut down all the trees, and grub up any scrub palmettoes that may be growing under them. The big wood is then to be drawn into heaps and burned, the smaller stuff to be piled around the stumps and left there. After a while the stumps will dry and begin to decay, and the branches around them will become as dry as tinder. The heaps can then be fired, and the stumps will be at least partially destroyed. One or two such burnings will remove all trace of them. It is said of pine stumps that they will never rot out. At any rate, they will keep their unsightly heads above the sand for many years, unless burned off; but they do no harm. The new settler, upon finding himself suddenly the owner of fifty acres of pine woods, often imagines that the wood itself must be valuable, but it does not take him long to get rid of this notion. When the pine is cut into stove lengths, seasoned, split, and delivered in town, it is worth $4.50 a cord; but the money is for the labor, not for the wood, and purchasers are few. People are not foolish enough to buy wood when they can go into the nearest forest and cut all they want. It would have some value in the shape of boards, but there is no saw mill handy. Possibly the railroad will buy a few cords of it. The upshot is that most of the cut wood is burned to get it out of the way.

Some of the pine is saved for fence posts. The fence is a less serious matter in Florida than almost anywhere else. Cattle roam freely through the woods, and every orange grove must be fenced, or the half-wild animals will eat and kill the young trees. To have fence posts cut costs two and one-half cents each, but the newcomer cuts his own posts out of his own trees, and they cost him nothing. Later he will have iron posts, each post securely set in a block of artificial stone, but for a beginning pine posts answer the purpose, with three strands of barbed wire stretched over them. Time was when barbed wire cost five or six cents a pound, but now it is down to two and one-half and three cents, and the fence is the cheapest part of an orange grove. The "wickedest" sort of barbed wire is used, with prongs nearly an inch long, and men and animals alike treat it with all the respect it deserves. Wire to fence ten acres costs about twenty dollars; and after the posts are cut it is not more than two or three days' work to put it up. A man accustomed to farm work can clear his ten acres, cut his posts, and put up his fence in one month.

At this point the settler begins to feel the need of a horse or a mule, and generally he buys one if he can. There are excellent draught animals in Florida, but on new groves made by poor men an anatomical curiosity is generally chosen. He is cheap, and he has a happy faculty of feeding upon green leaves, twigs, Bermuda grass, pine cones, or whatever falls in his way. A horse is not absolutely necessary, for most of the neighbors own one or more, and are only too glad to hire one out for an occasional day's work. The first work of the horse or mule, with the man trailing on behind, is to plow the ten acres that have been cleared and fenced. For a man who has been accustomed to farming in any solid soil, plowing the soft sand of Florida is mere recreation; to the New England farmer it is positive pleasure. It is like plowing snow, without the cold or slipperiness.

Now comes a strain upon the new settler's mind. Shall he plant seedlings or budded trees? and if the latter, shall they be Mediterranean sweets, Hart's tardy, homosassa, the nearly seedless Jaffa, Boone's

early, Belair star, Maltese oval, early Spanish, magnum bonum, navel, tangerine, mandarin, grape fruit, pomelo, blood Maltese, or the plain blood? These are only a few of the varieties he may choose among. The difference between a seedling and a budded tree is no longer a mystery to him. The seedling, he knows, is just a plain orange tree raised from the seed, a little hardier than any of the budded trees, and to some minds not quite so good. A budded tree is a grafted tree, only the term grafted is not used in reference to trees that do not shed their leaves. A bit of bark on a young shoot is raised, and a tiny bud of the desired variety is fastened in; that makes a budded tree. It is not so much the kind of fruit as the time of its ripening that must decide him in his choice. He wants some fruit ready for market early in the season, in the hope of high prices, and for this he selects perhaps Boone's early. But there are good prices late in the season also, and to meet this demand he chooses something like Hart's tardy. This is an orange that will hang on the trees till August or September, and retain its good qualities. The beginner, if he follows good advice, selects a half dozen varieties, perhaps more; and they are sure to include some mandarins and tangerines, a few blood oranges, and some grape fruit.

It is to the nurseryman that the beginner must now go; and nurseries are plenty all over the orange country. The trees usually set out are from four to five years old, and at that age they are delicate things from one to two inches thick in the trunk. The nurseryman keeps the trees all ready budded, so the new hand need make no experiments at that work. A few years ago he charged from $1 to $1.25 for a budded tree five years old; but there is so much competition now that prices are cut, and such trees sell for about 20 cents each. The prospective grower has learned that seedlings must be set out 30 feet apart each way, and budded trees 25 feet apart. With this knowledge he easily finds that he will need sixty trees to the acre, or 600 trees for his ten acres, which cost him $120.

Laying out the land furrows that will work to the best advantage is always done with care, for crooked rows are unsightly forever after. Straight rows at right angles are most in vogue, although there is a system of alternation by which four or five more trees can be planted to the acre. This is called the circular system, perhaps because it is entirely angular and gives no hint of a circle. When the trees are drawn in both directions, a tree is to be set out wherever the lines cross, and the planting is done entirely by hand. There is no preparation of the soil, except the plowing, and the only implement used is a hoe or a shovel. The man scrapes a hole, sets in the tree, pulls the sand over its roots, and the tree is set out. The one thing in planting that requires particular care is the depth to which the trees are set. The sand must not be drawn up around them in a hill, and each tree must be about one inch higher, one inch further out of the ground, than it stood in the nursery. If this is not attended to, the trees will grow scaly and suffer from wood lice and other undesirable things.

When the 600 trees are carefully set out the beginner imagines that his grove is started, but this is a great mistake. The sandy soil does little more than hold them upright; it does not contain enough nourishment to give the trees any vitality. The nourishment must come from the outside, through the air, the rains, and the use of fertilizers. The fertilizing question was once puzzling to the orange growers, but the State has come to their rescue and made it easy, though it is still expensive. Every commercial fertilizer sold in the State is examined by the State Chemist, and a report of the analysis is published, so that the grower knows just what he is buying. Forty dollars a ton is the price of the half dozen standard fertilizers, and from this the price goes down to $15 or $30 a ton for inferior grades. But in all cases the price is practically the same, because it takes two tons of $20 fertilizer to do the work of one ton of $40 fertilizer. The fertilizer lies unnoticed in the sand till the first rain falls, then up comes a crop of grass and weeds. Ten days after a rain the new grove is as green as a lawn, and the grower must turn out with his hoe and hoe all around the trees, taking care not to bank the up. The object of this is to keep the sand loose around the trees. He is hardly done hoeing before there comes another rain, and more grass and weeds appear, and he must bring out the cultivator. Three times in the first year he must give each tree its food of one pound of fertilizer; four or five times he must hoe around the trees; five times in the spring he must run the cultivator all over the grove; and after letting the grass grow throughout the summer, he must plow it under in the fall. This is the routine for the first year. Planting an orange grove and letting it grow is capital occupation for a lazy man, but there is no money in it; planting a grove and making it grow keeps an industrious man busy.

In the second year the cultivation is the same as in the first; three times fertilizing, five times cultivating, five times hoeing, and one plowing. But in the second year each tree must have two pounds of fertilizer each time. It is the same in the third year, with three pounds of fertilizer each time; fourth year, four pounds; fifth year, five pounds. In the fifth year after setting out the trees should begin to bear a stray orange here and there, and then the quantity of fertilizer must be increased. Sixth year more oranges and more fertilizer. Seventh year, still more. In the eighth year after setting out the grove should give a very respectable crop. In the tenth year, if well cared for, it is in full bearing. Even before the fifth year there may be enough oranges to make a showing, with more each succeeding year.

By the end of the tenth year the grower has spent almost exactly $2,000 in money in the making of his ten acre grove and has done in the neighborhood of $3,000 worth of work upon it. It is worth now $5,000, and will sell readily for that. As a money producer it should give him $800 a year profit, not counting his own labor, which becomes lighter as the trees grow older. The old grove needs only one fertilizing a year, at the rate of a ton to the acre, one plowing, two or three cultivatings, and occasional pruning. The ten tons of fertilizer a year cost $400, and the grove should produce 1,200 boxes of oranges, worth at least $1,200. This is an average; sometimes—that is, some years—600 trees will produce nearly double that, and other years not so much. Two boxes to the tree is a fair average for ten year old trees, counting the years when the fruit is injured by frost, by blight, insects, or other things. A dollar a box is a low estimate of the value of the oranges, sold on the trees before they are ready to pick, the picking and packing to be done at the expense of the buyer. By having them picked himself and sending them to market the grower may often realize $2 a box for them; but in this case he runs the risk of striking a bad market and getting almost nothing.

When the trees are ten years old they are almost as safe an investment as government bonds, and give larger returns. They are then, humanly speaking, beyond the reach of harm. A severe freeze, such as came in 1835 and came again in 1894, ruins the crop on the trees, but does not materially injure the trees. Before they have come into full bearing, however, the trees have various risks to run. A hard freeze like last year's may kill them down to the ground, leaving the roots still in good condition, or they may suffer from blight, footrot, dieback, scale insect, or red spider. There are remedies for all these things, and the careful cultivator fights them off. Fertilizer containing too much ammonia, for instance, causes the dieback, in which the trees retrograde instead of advancing.

The cultivation described here is the best known, leaving irrigation out of the question. Irrigation is for the fancy grower in Florida, the capitalist who raises oranges because they are pretty, not for the man who makes a living out of them. Fertilizing is the main point. Gradually the grower learns that one fertilizer makes his orange skins smooth and bright, another rough and dark. One advances the trees rapidly, but injures the fruit. By the time his grove bears well he is familiar with all these things, and if he is as smart as he ought to be he can produce exactly the kind of orange he desires, which is the one that brings the best price. He can raise "Indian Rivers" in Orange County as well as further down the State, for most Florida oranges are Indian Rivers by the time they reach the consumer.

If the man can assure himself an income of $800 by setting out a ten-acre grove, why not make the income $2,400 by setting out a thirty-acre grove, especially as he can cultivate thirty acres as well as ten? It is all a question of means. If he can raise the money, he had better do it. It is not to be forgotten that he must support himself and probably a family while he is waiting for the trees to bear. This is not so hard as it looks, in a warm country like Florida. Dressed pine lumber sells here for $10 to $12 a thousand feet, and a comfortable dwelling house can be built for $300 or $400, a smaller and poorer house for much less. The sweet potato patch, a never-failing bank account in this section, removes all possibility of hunger. The kitchen garden is a great help, with its bearing capacity of twelve months in the year. There are excellent fish in the lake, and in the woods, his own woods, are deer, squirrels, rabbits, and birds without number. There is ready sale for all these things, for in nearly every two mile circle there is at least one winter hotel in need of fresh food. The poultry yard and the beehives, when properly managed, readily turn in the $200 of money needed every year for the grove.

The thing has been done so often that the feasibility of it is beyond question; it is doing now, on a thousand little groves in this country. It is a pull to do it without sufficient capital; but it is always a pull for a workingman to turn $2,000 into $5,000, especially when he has first to earn the $2,000.

[Continued from SUPPLEMENT, No. 979, page 15644.]

DEVELOPMENT OF MINERALOGY.—V.

By L. P. GRATACAP.

PROF. PATTISON MUIR has pointed out with great care the growth of a true chemical conception of "salt" as a chemical fact. It was recognized at quite an early period in the eighteenth century that the salts were combinations of an acid and a so-called alkaline or earthy principle, but the subject was clouded over by ignorance as to the real facts of the case. Then came the advanced views upon combustion introduced by Lavoisier, with the kindred facts of oxidation throughout the range of metallic bases. The acids were regarded as oxygen compounds and the bases as oxygen compounds, which in combination produced salts which were also oxygen compounds. Davy furnished the brilliant generalization that the acid element of a salt was electro-negative and the alkaline, earthy, or metallic, electro-positive, while his decomposition of the alkalies and the earths and the production of their metallic bases threw into a common category all of them. His theory led to the thought that the salts were the unions of oppositely electrified bodies which thus secured between them electrical equilibrium. Then followed the discovery of chlorine, the composition of hydrochloric acid and the gradual withdrawal of the assertion that all salts were oxygen compounds, since muriatic acid formed salts and it contained no oxygen, and it formed them directly with the unoxidized metals. Berzelius continued these speculations and constructed the great system of dualism in chemistry. He regarded all atoms of substances as possessing both kinds of electricity accumulated at their polar extremities, but that one or the other, positive or negative, preponderated, and that the affinity of the atom was determined by that preponderance. If the atom was negative in excess, it attracted an atom in which positive electricity prevailed, and so on. He then continued building up compounds from these primary combinations; compounds of the first order were made up of the combination of atoms of two or more (organic) elementary atoms; compounds of the second order were made up by combinations of elementary atoms with the compounds of the first order or by the combination of two or more compounds of the first order; compounds of the third order were made up by combinations of two or more compounds of the second order. These views overthrew the Lavoisierian conception of oxygen as the acidifying element and they led Berzelius in the course of his experimentation to detect the acidic character of silica. Silica, thus revealed as playing an acid role, introduced a whole new range of ideas in reference to mineral compounds and the widely distributed silicates were for the first time given a truly systematic position.

Cronstedt had, years before, attacked the determination of minerals and had devised a system of blowpipe examination which was most fruitful in revealing the more evident features of the minerals as they were found in the field. His little laboratory comprised the blowpipe, a candle, a pincers, three flasks with a few reagents, as borax, carbonate of soda and microcosmic salt; a hammer, a steel plate, a magnet, a file, a magnifier, completed his equipment, with charcoal as a surface for holding the specimens tested. It is surprising to learn in this early treatise on blowpiping by Cronstedt how far this sort of mineralogical research had advanced and how careful and accurate are the directions given by its author for the detection of combinations and peculiarities of reaction. The zeolites were first in their peculiar chemical behavior separated by Cronstedt, who pointed out that they dissolved in nitric acid and that the solution possesses the peculiar property, after some time, of assuming the consistency of a jelly, which will not fall out of the vessel containing it, when the former is inverted, referring to the familiar gelatinization of these hydrous silicates when decomposed by acids.

Lehman, a German mineralogist and chemist, had also applied his studies to the separation of metals and their compounds and to their various natural occurrences. He believed that in all bodies there were three separate principles—the vitreous, which formed the greater and more solid portions, the combustible, upon which depended malleability and fusibility, and the vaporous-mercurial, which imparted metallic luster and weight. Marggraf, Scopoli, Bergmann and others developed the chemical side of mineralogy, though for the most part their investigations were with the metals and metallic compounds, and the more common earths—the clays, sands, quartzose rocks, limestones, and iron oxides; while the precious stones began to play a part in the experiments of the chemists. Klaproth, whose work extended into the nineteenth century, added a new and brilliant list of investigations by the results of which the oxides or earths of uranium, zirconium, strontium, titanium and cerium were placed in the catalogues of mineral bases.

In 1774 the great Werner, the Professor of Mineralogy and Mining at Freiberg, published his celebrated essay on the "External Characters of Minerals," in which he undertook to define in detail those features of minerals, other than chemical and physical, which appertain to color and form. Werner separated the colors of minerals in a long list of varying shades which seem somewhat superfluous and are seldom constant in one species; thus white was distinguished under the following variations:

Snow white.—Quartz, flos-ferri, cerussite.
Reddish white.—Kaolin, steatite.
Yellow white.—Zeolites, white amber.
Silver white.—Native silver, bismuth, arsenopyrite.
Greenish white.—Talc, amianthus.
Milk white.—Opal.
Tin white.

In green he recognized wood green, mountain green, grass green, apple green, leek green, siskin green; in yellow, sulphur yellow, citron yellow, gold yellow, straw yellow, wine yellow, Isabella yellow, ocher yellow, orange, and so on with similar elaborations in gray, black, blue, red and brown. His efforts at the separation of crystals were not permanently valuable; he mentions six fundamental forms, the twenty angled, the eight angled, the prism, the pyramid, the table, and the wedge. Cleavage, transparency, solubility, and hardness were determined by him for many minerals, and upon this kind of analysis he reformed the current systems, and attempted the establishment of a fixed nomenclature. His fame spread through Europe, students flocked to his instructions and a new group of mineralogists issued from the doors of the Freiberg Institute that were in their turn destined to advance the science. Among these were Andrada, Jameson, Breithaupt, Brochant, Karsten, Weiss, and others, all of whose labors have been commemorated in the science in mineral species bearing their names.

While advances were thus constantly claiming the attention of the chemical mineralogist, the physicists were pushing the crystallography of minerals to the final stages of its development. The work of Steno was continued by Rome de l'Isle and Hauy, and when the latter at the beginning of this century published his first edition of the "Traite de Mineralogie," the science of crystallography was practically accomplished. Certainly much was added, and the optical properties of minerals were to receive large additions, but the theory of the synoptical systems had obtained from Hauy a full and patient exposition.

Rome de l'Isle measured an extraordinary number of crystals, and determined the invariability of the crystalline angles, the derivation of secondary forms from primitive ones, and assumed the reference of crystals to six leading forms: the tetrahedron, the cube, the octahedron, rhombic prism, rhombic octahedron, and hexagonal pyramid. He proved the symmetry of crystalline faces, the twinning of crystals, and illustrated it in gypsum, zircon, staurolite, feldspar, spinel, marcasite and cassitente. He understood the nature of pseudomorphs and relied upon chemical analysis for those distinctions in composition which separated mineral species of the same crystalline habit.

In the closing years of the eighteenth and the opening years of the nineteenth century, the development of mineralogy was rapid and various, and in no feature more remarkable than in crystallography. Hauy pushed this fundamental principle in mineralogy the farthest and put crystallography in possession of those conceptions which were needed to open the way to a philosophic treatment. For instance, in the isometric system he described the process of decrescence, by which a cube declines through the truncation of its angles into an octahedron, while its faces produced in diminishing pyramids produce the rhombic dodecahedron. This led to the mathematical calculation of possible faces and gave to the crystallographer the power of prophecy, and in the calculation of angles the means of verification. Hauy devised a system of symbols, no longer used, determined the rational relation of the axes of different pyramids and prisms, beginning with some base form, pointed out

that hemitropes or revolved forms were revolved upon a geometric plane, and the law of symmetry, by which a modification of one part of a crystal imposes a similar modification upon similar parts. Hauy successfully applied his crystallography to the determination of species, and his correction of previous errors of identification was sustained by chemical analysis. The zircon of Norway, regarded as vesuvianite, was determined by Hauy; he showed the specific character of euclase, separated meionite from hyacinth (zircon), separated the minerals compounded under the name of schorl, united the various forms of specular iron and divided the isometric (pyrite) from the orthorhombic (marcasite) form of iron sulphide.

Hauy's views and system were not received without opposition, even by well experienced crystallographers, but his new and exact results stimulated students, and there were published several systems of crystals differing from his. Weiss, who undertook the translation of Hauy's mineralogy into German, devoted his life to crystallography, and he emphasized the nature of crystalline axes or directions along which with varying intensities the crystalline forces act. It was Weiss who developed the crystalline categories of hemihedrism. Hauy had formulated a system of determinants for crystals based upon the relations of various dimensions other than the axes, as in rhombohedral forms the relations of the diagonals of the faces, in hexagonal forms the relation of a normal from the center of the base to one side, to the height, in tetragonal forms the relation of a side of the base to the height of the prisms, in pyramids the relation of one-half of a side of the base to half the height, in orthorhombic crystals the relation of half the side of the base to half the height.

Weiss expressed the position of a crystalline face by its reference to the three axes of the crystal. The axes became its co-ordinates and the face was determined by the points of intersection made by it with them. This system was simple, comprehensive and natural. It enters into the nature of all succeeding systems, and assisted methods of mathematical calculation. Neumann, one of the most distinguished of the disciples of the Weiss school, fixed upon the normals produced from the center of a crystal to the faces as affording means for the delineation of the crystal. These normals projected intersected the surface of an imaginary sphere, embracing the crystal, and the horizontal projection of these points of intersection prepared the geometrical solution of the crystal.

Weiss had called the attention of crystallographers to the importance of zones, viz.: Groups of planes between which the edges or mutual intersections are parallel, but it was Neumann, to quote Prof. Fletcher, who "proved that the fact that all possible crystal faces can be derived by means of the intersection of zones is a necessary consequence of the rationality of the indices; that, indeed, the law of zones is mathematically identical with the law of rationality."

The succession of distinguished thinkers in crystallography was now very striking. Hausmann, Mohs, Haidinger, Miller, Bernhardi, Quenstedt, Breithaupt and others, investigated the nature of crystalline structure in its geometrical relations and endeavored to reduce it to a system of mathematical definition, while they severally adopted plans of notation by which crystals could be described. Among these celebrated men, many of them gifted with extreme mathematical insight, Mohs may be regarded as the greatest. He especially discussed the problems of crystallography. He established the six systems which crystals assume, he proved the existence of the inclined systems, an honor shared with him by Weiss, and he described the mutations of crystalline combinations more fully than had been done before. Mohs endeavored to bring into harmonious arrangement the system of mineral species with the systems of botanical and zoological species, and to establish generic and specific names based on the Linnæan invention of binomialism. It was a fruitless and misleading effort, and only introduced an alien system which confused and delayed the progress of the science.

While crystallography was thus making rapid strides in advance, and it demanded the highest intellectual strength to follow the speculations of its professors, mineral physics was accompanying it in a sympathy of development that expressed the close relationship of one with the other. When the six crystalline systems had been established on geometrical grounds, it was felt that their virtual existence required a stronger corroboration from physical properties, especially optics. The limits of the uniaxial and biaxial crystals was a wider boundary than the systems indicated, and it was desirable that in the biaxial systems—the orthorhombic, monoclinic and triclinic—differences of optical reaction should be discovered marking off one from the other. Neumann and Herschel established the validity of the systems. It was found that in orthorhombic crystals the two lines bisecting the angle of the optic axes internally and externally, and a third line perpendicular to both, are constant in direction in the crystal, whatever the color of the light; in the monoclinic only one of these lines is constant, as the color varies; in the triclinic none of the three lines has any constancy of direction (Fletcher). Brewster, Haidinger, Biot, Malus, Senarmont, Herschel and others were investigating the double refraction of crystals, the polarization of light, its circular distortion, pleochroism, by which in the line of different axes the light was differently colored, the anomalous behavior of crystals which contradicted the usual law of their system.

For instance, chabazite afforded both positive and negative double refraction, penninite gave very different angles between the optical axes in different specimens, twinning crystals which should be biaxial appeared uniaxial, crystals without normally double refraction possessed it. These peculiarities and contradictions afforded the physicists numerous problems whose solutions were followed by a wonderful series of further optical discoveries. It was shown that the lamellar overgrowth of crusts of new material produced polarization by reflection from the interlamellar surfaces, that heat and pressure influenced the optical properties, that the angle of the optical axes in biaxial crystals changed with the color of the light. Then came the discovery of elliptical polarization, conical refraction, asterism and the peculiar Brewster figures which Babinet showed was the result of diffraction. The electrical properties, elasticity, gravity, density, phosphorescence and other physical properties were being, at this stage in the history of mineralogy, closely studied. The relations of the axes in the various systems were found reflected in the physical reactions of minerals in different axial directions. Thus in expansibility the crystals of the isometric system expand in all directions equally, in the hexagonal the expansion in the direction of the principal axis is different from that in the lateral axes, in the orthorhombic the expansion is variable along all three axes. The hardness of minerals was also found a property unequally developed upon different faces of a crystal, and the differing electrical properties of the opposite ends of the hemimorphic tourmaline had been detectected by Hauy, while Brewster showed the pyro-electricity developed upon heating a long list of minerals.

Phosphorescence and fluorescence were investigated in minerals. Brewster demonstrated that some fluorites were phosphorescent in parts or veins, while Pearsall showed that many minerals which failed to display phosphorescence through ordinary heating became phosphorescent through an electrical shock.

Isomorphism and polymorphism were now extensively investigated, and the singular fact that the temperature of the crystallization influenced the crystalline form was soon announced, results prophetic of the singular properties of boracite made known by the studies and experiments of Ernest Mallard. It was proved from his observations that above 265° boracite is isometric and below that temperature orthorhombic. In this latter instance, and of very recent discussion, the orthorhombic elements are assumed to be almost cubic in their proportions, so that a slight readjustment of the molecules leads to an inversion of one form to the other. Amorphism and pseudomorphism were also ingeniously studied, and speculations framed to meet their various problems, while a peculiar condition, named by Scheerer as paramorphism, was described, wherein a mineral having one general exterior form incloses constituents having a different crystalline character. He instanced a natrolite of Norway which was orthorhombic, but assumed a monoclinic habit.

The occurrences of minerals were industriously examined, and in the middle of this century a host of observers were steadily acquiring facts as to the interchanges, relations, and physical features of minerals, which gave the science an almost new aspect. Among these were Fuchs, Haidinger, Scheerer, Delesse, Bischof, Breithaupt, Dana, Kenngatt, Sorby, Von Rath and many others. Daubree, Senarmont, Rose, and others scarcely less distinguished were now reproducing minerals and invoking every kind of chemical reaction to build up in the laboratory the minerals of which the chemists had already furnished the composition. In short, the modern epoch of scientific thought revealed in mineralogy a most diversified field of experiment and observation. But chemistry more and more inclosed the domain of mineralogy, and in the extension of analyses, the discovery of more exact methods of analysis, new species were being constantly added, while at last a norm of reference became established as to the relationship of minerals, and so the modern chemical classifications slowly emerged.

The modern movement in the widening and deepening studies in mineralogy has gone on unceasingly, and now in its crystallographic relations the treatises on symmetry have attacked the problems of molecular form and position, and in its chemical aspects began those speculations upon the evolution of mineralogical types in which Tschermak and Clarke have offered distinguished assistance.

Whereas in 1832 few minerals were in composition free from all dispute, now chemical formulæ are exactly determined, and the great groups of the amphiboles, pyroxenes, scapolites, garnets, micas, feldspars, have been defined. The tendency has been to make mineralogy a chemical science, and it seems to grow constantly clearer that in chemical composition is to be found most of the determinative characteristics of mineral species. The dependence of physical or optical qualities upon composition has only recently been demonstrated in a paper by Prof. Penfield, who has shown that the varying inclination of the optic axes of topaz arises from the varying amounts of fluorine present.

It may finally be claimed that in a sense mineralogy approaches a finished science. Special investigations may extend the list of species, or reveal qualities in old ones not hitherto suspected, but its broad outlines are drawn and they are solidly filled in. The future development of mineralogy lies in the field of paragenesis—the associations and affinities of minerals—and in the synthetic production of them and their pyrogenetic history.

SCHMIDT'S THEORY OF THE SUN.

ACCORDING to this theory, the sharpness of the sun's limb and the enormous change of brightness at that place are not caused by correspondingly abrupt changes in the constitution, density or light-radiating power of the solar matter, but are the result of refraction in a non-homogeneous medium. The well-known "fish-eye" problem of Maxwell deals with conditions of the same kind, and in general the phenomena of refraction in a non-homogeneous medium are very complicated and remarkable. Thus the sun, according to the theory, although sharply bounded as seen by the eye, is in reality a gaseous ball, whose density diminishes indefinitely and without any sudden transitions, with increasing distance from the center. In other words, the photosphere is an optical and not a material surface.

The gaseous sphere considered by Mr. Wilczynski is a purely ideal one, and additional interest would have been given to his paper if it had been shown that the required conditions are perhaps fulfilled in some of the heavenly bodies. Various assumptions as to mass, temperature, etc., are here necessary, which it is usually impossible to verify, but Dr. Knopf has shown in his paper on this subject in A. N. 3,199, that the conditions in the case of the sun are well within the bounds of probability. Even in the case of Jupiter, circular refraction would occur if the atmosphere were only a fraction as dense as that of the earth.

But however difficult it may be for present theories to account for the tenuity of the solar atmosphere immediately above the photosphere, and however readily the same fact may be accounted for by the theory of Schmidt, it is certain that the observer who has studied the structure of the sun's surface, and particularly the aspect of the spots and other markings as they approach the limb, must feel convinced that these forms actually occur at practically the same level, that is, that the photosphere is an actual and not an optical surface. Hence it is, no doubt, that the theory is apt to be more favorably regarded by mathematicians than by observers.

In its application to details, so far as this has been attempted, the theory is not very satisfactory. Schmidt's explanation of the prominences as a result of irregular refraction is rejected even by those who regard the general theory as a plausible one. Little better than this is Mr. Wilczynski's suggestion that the hydrogen and calcium forms of a prominence, which are so nearly identical as seen in the C and K lines, really occur at different levels, and are superposed by the effect of the peculiar refraction. In that case the hydrogen prominence would not even fall in the same vertical line with the calcium prominence which caused it. Here, again, the observer is convinced that he is not dealing with an optical effect, but that the gaseous forms which he sees actually occupy the same part of space.—J. E. K., in Astrophysical Journal.

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TABLE OF CONTENTS.